2005

Use of the Hybrid-Maize model to improve management decisions

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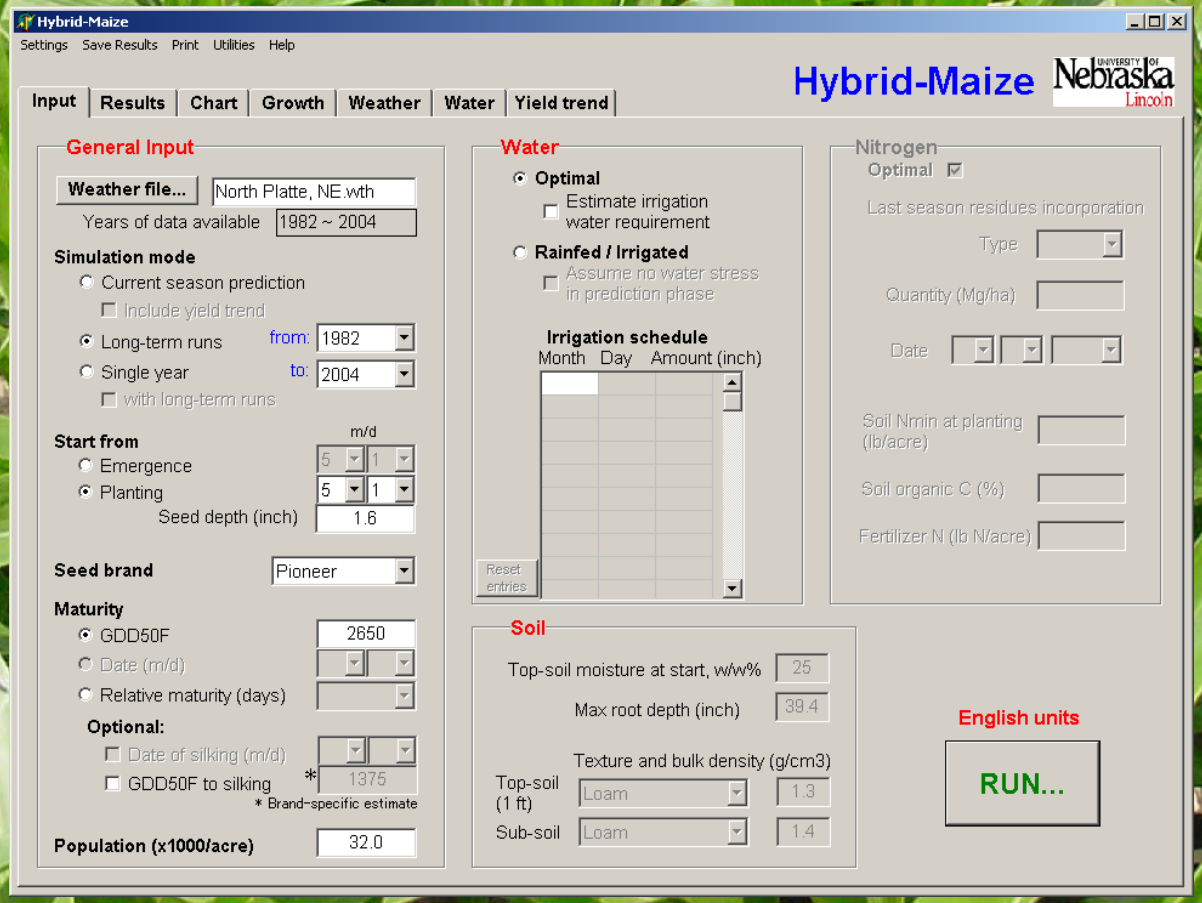
[2005]

Use of the Hybrid-Maize model to improve management decisions



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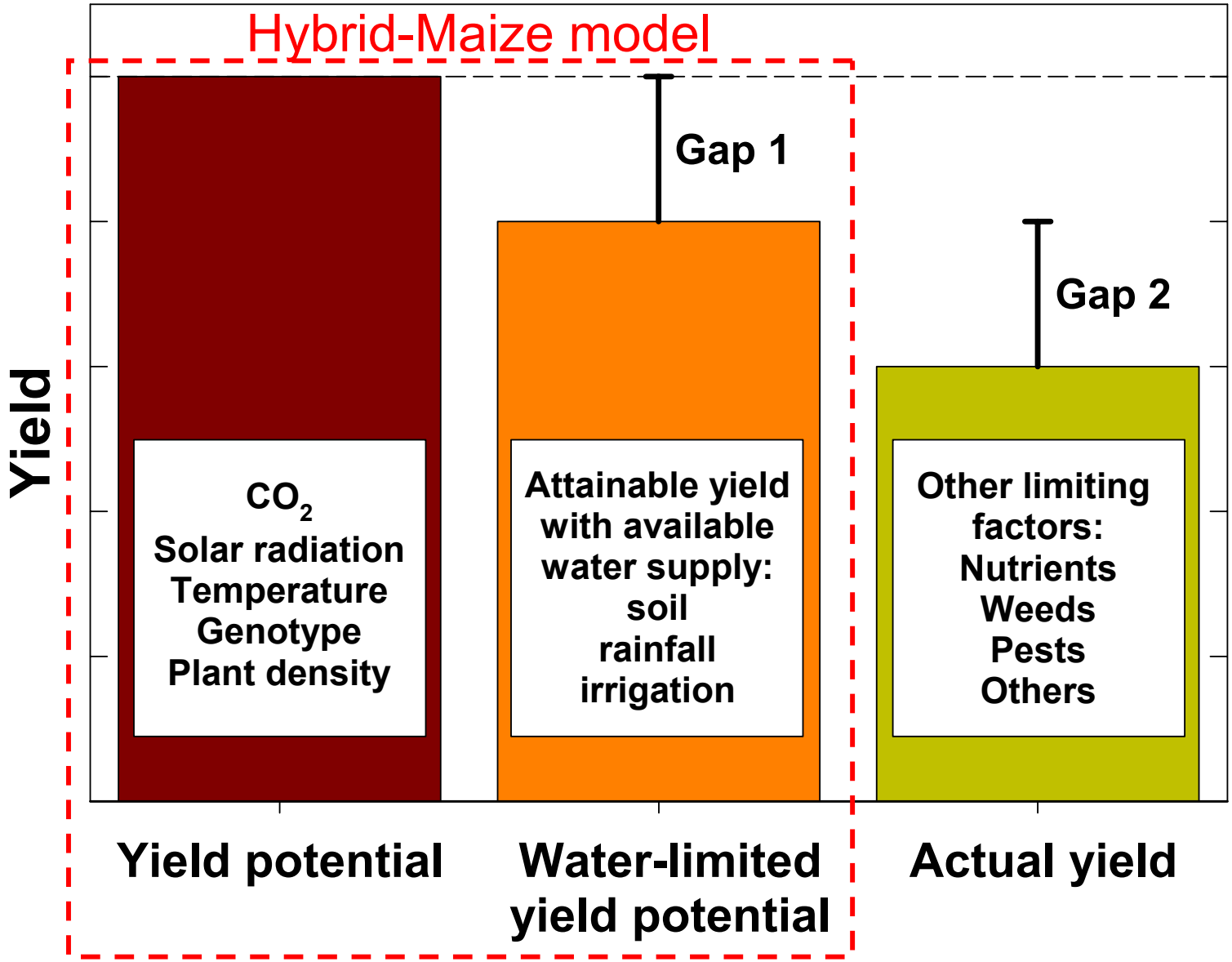
Digital Agronomy for Increased Yield and Profit

University of Nebraska Lincoln

- Yield potential and yield gaps
- Basic structure of Hybrid-Maize
- Model inputs
- Model applications
- Validation, uncertainties & future improvements

Outline



Yield potential and yield gaps

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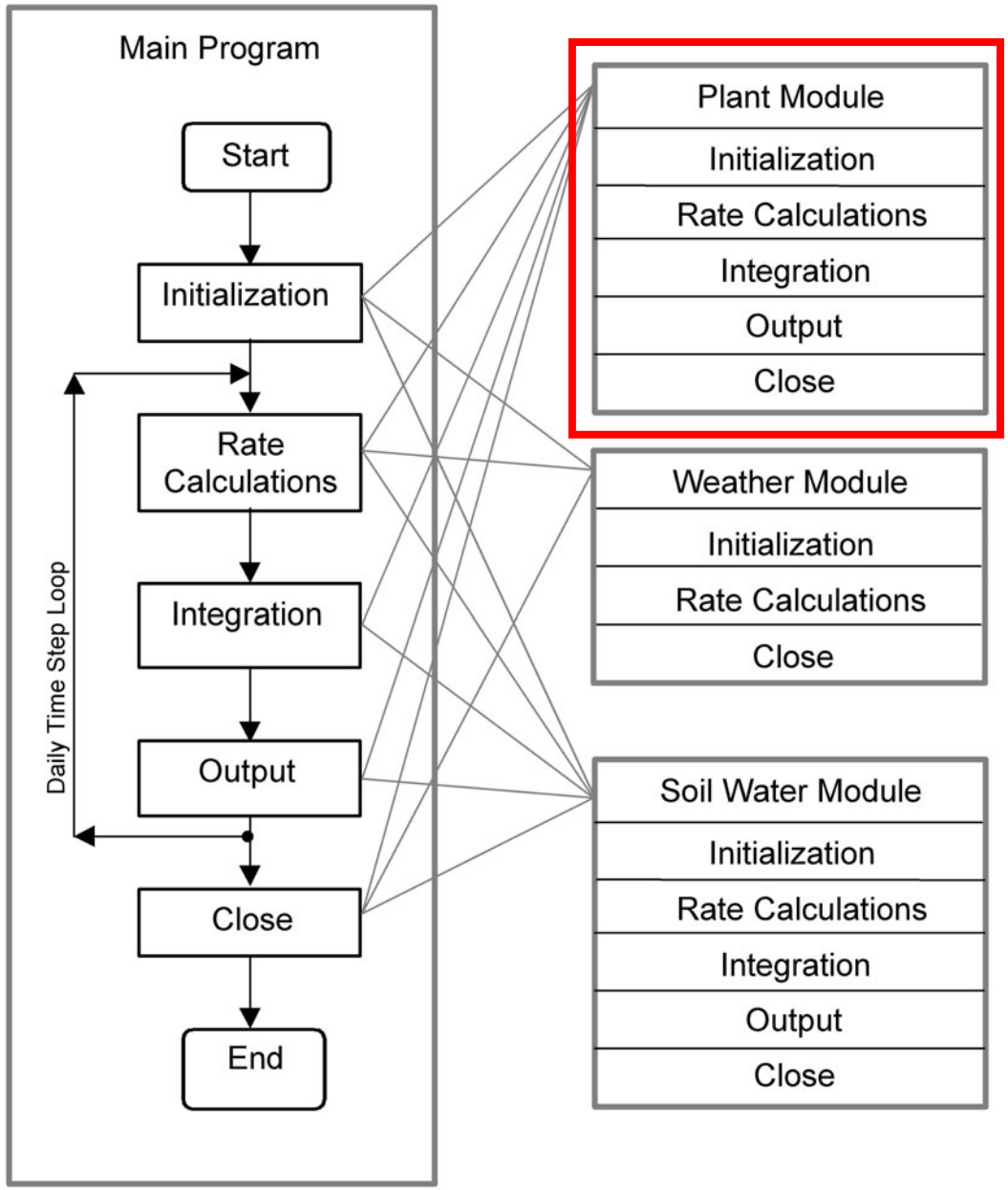
Crop simulation model: = a set of mathematical equations, which describe major processes of plant development and growth as a function of time, climate, and other factors

- Simulation of crop development: phenology & prediction of growth stages in vegetative and reproductive phases (e.g., emergence, leaf development, flowering, leaf senescence)
- Simulation of crop growth: gross and net dry matter accumulation in different plant organs (light interception, photosynthesis, growth and maintenance respiration, partitioning)
- With or without considering the influence of other factors on crop development and growth (water, nutrients)
- Most crop models operate on a daily time scale.

A simple crop-soil water model



Porter et al., 1999. An approach for modular crop model development
http://www.icasa.net/modular/index.html

- Vegetative phase:
  - Leaf number increase is calculated based on a maximum rate and actual temperature.
  - Continues until the plant reaches a genetically determined maximum leaf number.
  - Assimilates are partitioned between canopy and roots.
- Reproductive phase:
  - The difference between daily mean temperature and a base temperature is used to calculate the rate of plant development.
  - All growth occurs in the grain.
- All whole plant weight increases are converted to area based values by multiplying by the plant density.

Porter et al., 1999. An approach for modular crop model development
http://www.icasa.net/modular/growth.html

- Simulates growth and development of maize for yield potential and water-limited yield potential
- Combines two previous modeling approaches:
  - T-driven growth and development (CERES/DSSAT)
  - Mechanistic descriptions of light interception, photosynthesis and organ-specific respiration from generic models (Dutch school of modeling)

- Yang et al. 2004. Field Crops Res. 87:131-154
- Yang et al. 2005. Hybrid-Maize. A simulation model for corn growth and yield. Nebraska Cooperative Extension CD 9. University of Nebraska-Lincoln, Lincoln, NE. www.hybridmaize.unl.edu

Hybrid-Maize model

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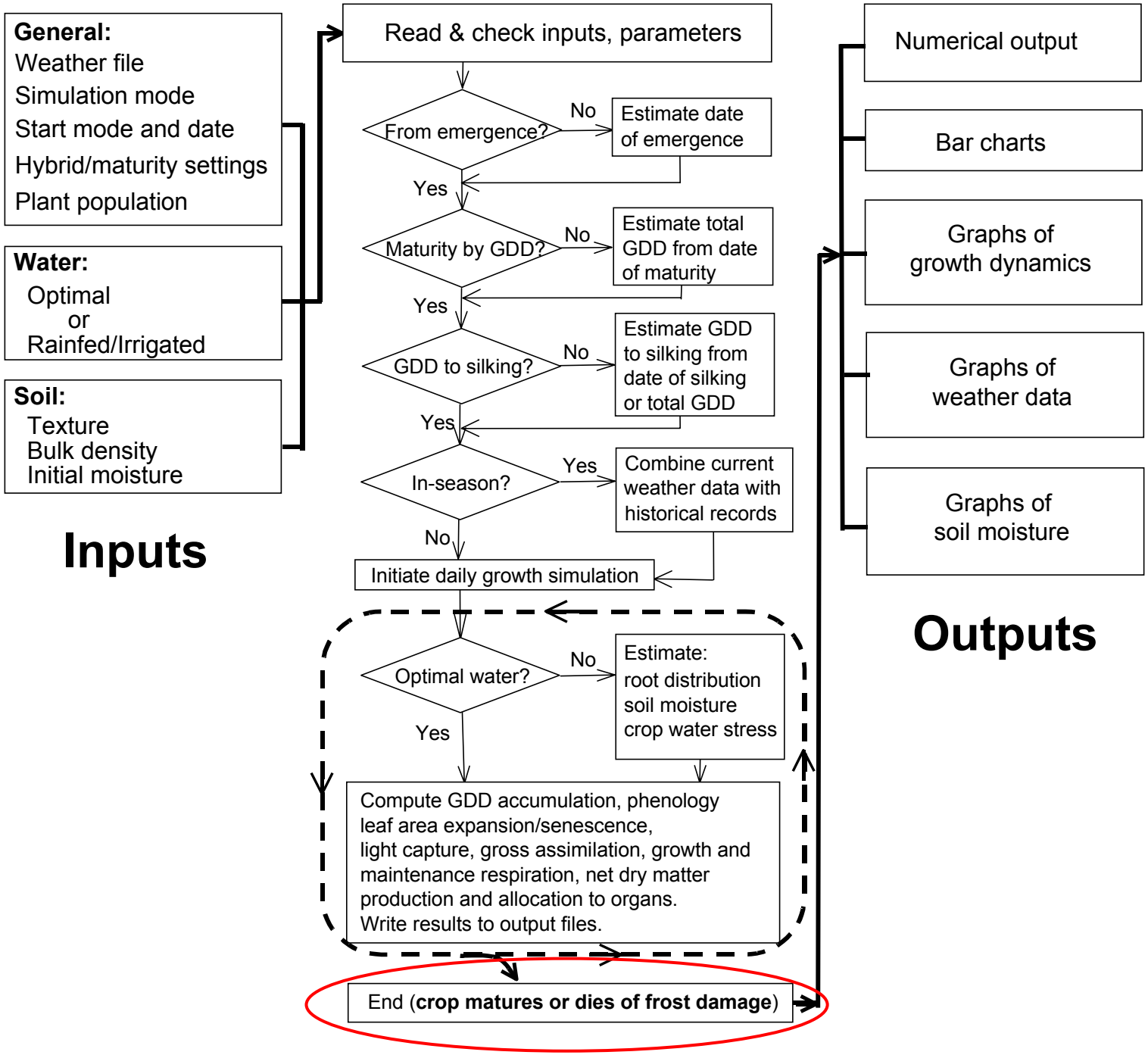
General:
Weather file
Simulation mode
Start mode and date
Hybrid/maturity settings
Plant population
Water:
Optimal
or
Rainfed/Irrigated
Soil:
Texture
Bulk density
Initial moisture
Inputs
Read & check inputs, parameters
From emergence?
No
Estimate date of emergence
Yes
Maturity by GDD?
No
Estimate total GDD from date of maturity
Yes
GDD to silking?
No
Estimate GDD to silking from date of silking or total GDD
Yes
In-season?
Yes
Combine current weather data with historical records
No
Initiate daily growth simulation
Optimal water?
No
Estimate:
root distribution
soil moisture
crop water stress
Yes
Compute GDD accumulation, phenology
leaf area expansion/senescence,
light capture, gross assimilation, growth and
maintenance respiration, net dry matter
production and allocation to organs.
Write results to output files.
End (crop matures or dies of frost damage)
Numerical output
Bar charts
Graphs of growth dynamics
Graphs of weather data
Graphs of soil moisture
Outputs

- Daily weather data: solar radiation, max. and min. temperature, rainfall
- Crop management: date of planting, seed depth, corn hybrid or GDD to silking/maturity, plant density
- For simulating water-limited yield: max. rooting depth, texture class and bulk density in topsoil and subsoil
- Optional: change model parameters
  - Hybrid-specific crop coefficients
  - General model coefficients describing crop growth and development
  - Soil physical properties for different soil texture classes

Hybrid-Maize inputs

Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

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Input | Results | Chart | Growth | Weather | Water | Yield trend

General Input

Weather file... August08.wth

Years of data available 1986 ~ 2004

Simulation mode

- (•) Current season prediction
  - [x] Include yield trend
- ( ) Long-term runs
- ( ) Single year 2004
  - [ ] with long-term runs

Start from m/d

- ( ) Emergence 5 1
- (•) Planting 5 12

Seed depth (inch) 1.5

Seed brand Pioneer

Maturity

- (•) GDD50F 2870
- ( ) Date (m/d)
- ( ) Relative maturity (days)

Optional:

- [ ] Date of silking (m/d)
- [x] GDD50F to silking 1440

Population (x1000/acre) 30.0

Water

- ( ) **Optimal**
  - [ ] Estimate irrigation water requirement
- (•) **Rainfed / Irrigated**
  - [x] Assume no water stress in prediction phase

Irrigation schedule

Month	Day	Amount (inch)
7	20	1.25
7	29	1
8	2	1.25
8	6	1.25

Reset entries

Nitrogen

Optimal [x]

Last season residues incorporation

Type

Quantity (Mg/ha)

Date

Soil Nmin at planting (lb/acre)

Soil organic C (%)

Fertilizer N (lb N/acre)

Soil

Top-soil moisture at start, w/w% 25

Max root depth (inch) 45

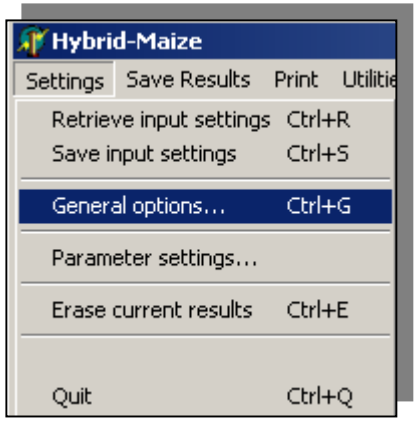
Texture and bulk density (g/cm3)

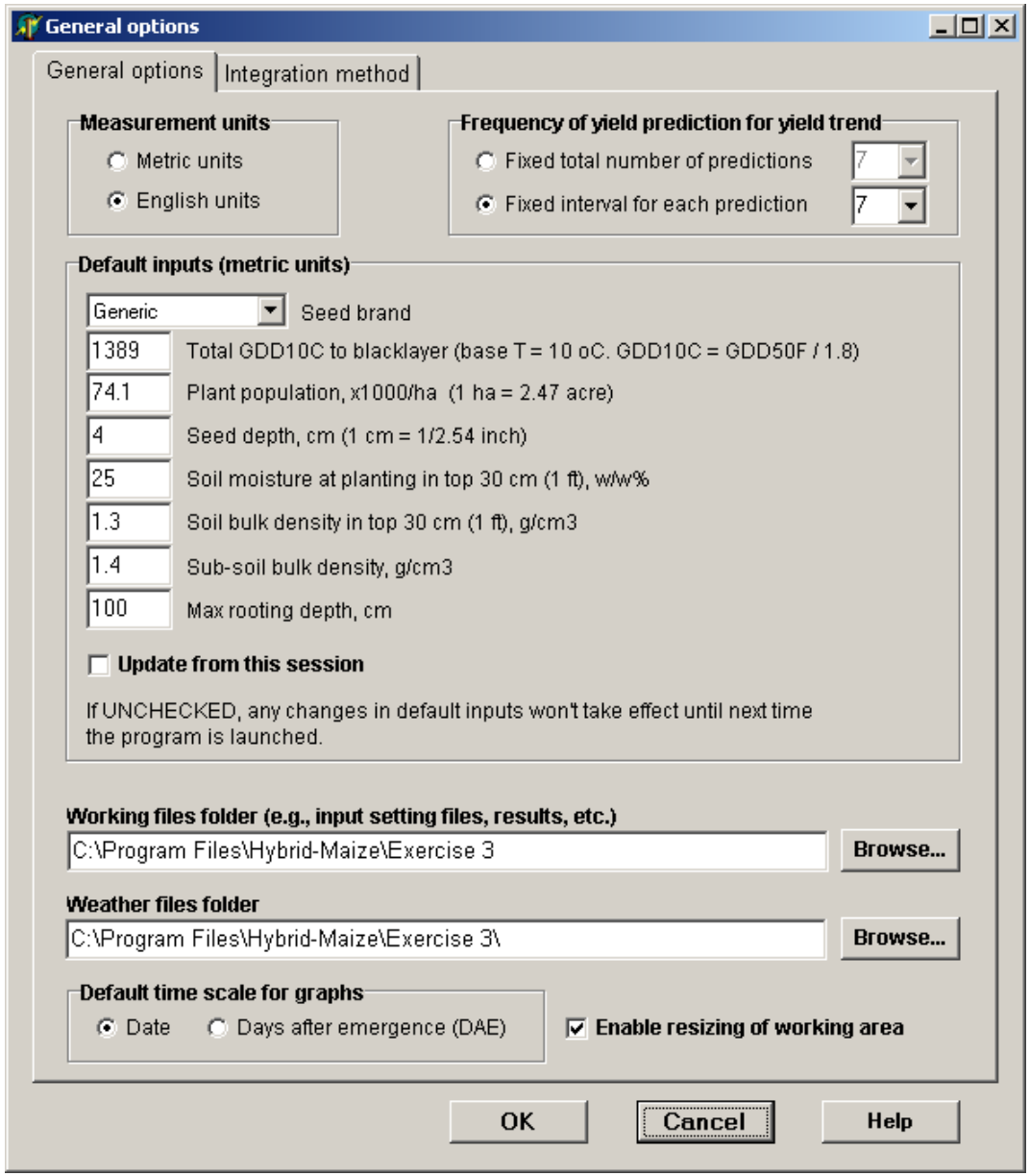
Top-soil (1 ft) Silt loam 1.3

Sub-soil Silt loam 1.4

English units

RUN...





Inputs: general options

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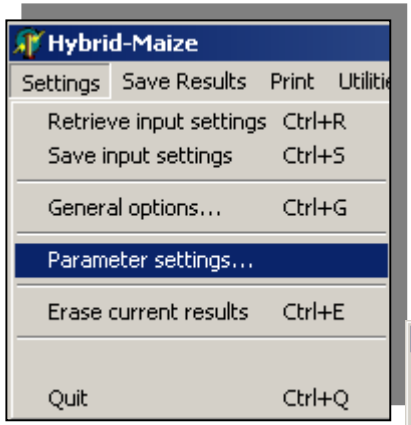

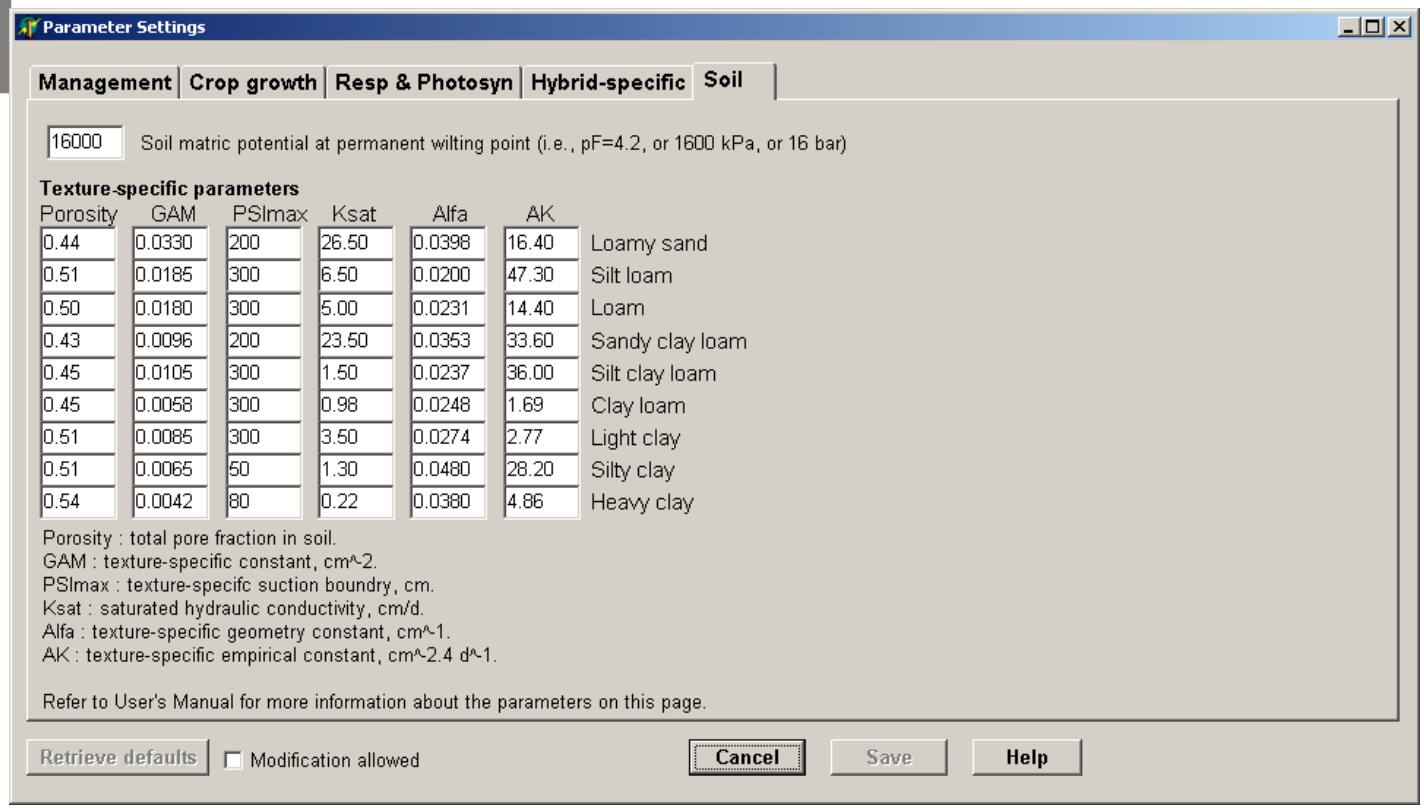

Inputs: parameter settings

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- Standard version includes long-term daily climate data for 15 sites
- Purchase Expanded Weather Database from estore.adec.edu (137 sites in 10 states of the Corn Belt), $25
- Subscribe to High Plains Regional Climate Center for online access to daily weather data (both long-term data and real-time data for the ongoing growing season), **hprcc.unl.edu**

Inputs: weather data

High Plains Regional Climate Center
University of Nebraska - Lincoln

IANR

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HPRCC supports a three-tiered national climate services support program. The partners include: National Climatic Data Center, Regional Climate Centers, and State Climate Offices.

www.hprcc.unl.edu

Quick Links

- Climatic Impacts in the High Plains
- Southwestern U.S Drought of 2002
- HPRCC Archive of NWS Stations
- Automated Weather Stations Information
- Nebraska Weather and Climate Information
- Lincoln, NE Weather and Climate Information

About HPRCC

(mission, objectives, activities, highlights, personnel)

Climate Data

(online, full service, AWDN, NWS, digital, hardcopy)

Climate Products

(current maps , normals, atlas, historical, national)

Research Projects

(NE soil moisture, crop coefficients, wind energy)

Publications

(articles, books, reports, extension)

Weather and Climate Links

(state climatologists, government, education)

High Plains Regional Climate Center
University of Nebraska
236 L.W. Chase Hall, Lincoln, NE 68583-0728
Phone : 402-472-6706, Fax : 402-472-6614

Inputs: weather data

University of Nebraska Lincoln

High Plains Regional Climate Center
University of Nebraska - Lincoln

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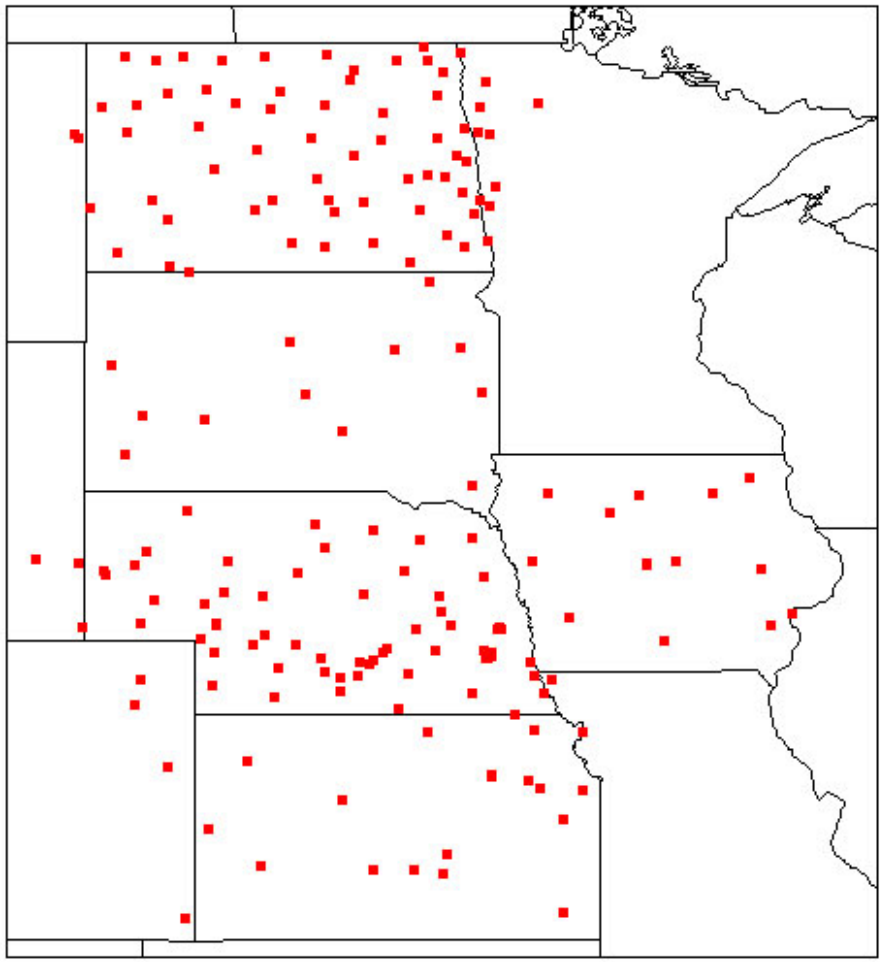
Automated Weather Data Network



Sites with automatic weather stations and long-term daily climate records, including solar radiation

Station Selection - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Back Search Favorites Media

Address http://[illegible]prcc.unl.edu/cgi-hpcc/stnsel.cgi Go Links

Select a [illegible]

- Raw Data Report
- Ag Data Report
- Single Variable Report
- Crop Dependent Report
- Insect Report
- State Summary Report
- Autopilot Setup
- Independent Delivery
- View Last Report
- View Account Information
- Example
- HELP

Search for, and Select a Station

Current Station List NORTH PLATTE WSO ARP,NE 1/ 1/1948 to 4/15/2002

Click Here to Blank the Current List

Station Selection List

AGATE 3 E ,NE 1/ 1/1948 to 4/15/2002
AINSWORTH ,NE 1/ 1/1890 to 4/15/2002
ALBION ,NE 1/ 1/1893 to 4/15/2002
ALLEN ,NE 1/ 1/1991 to 9/14/2000
ALLIANCE 1 WNW ,NE 1/ 1/1894 to 4/15/2002

Click Here to Add the Highlighted Station(s) to the Current List

Hold down Ctrl-key while clicking to select multiple stations

Identify a State Nebraska

Identify a Station Network National Weather Service & Cooperative Observer Network

Click Here to Search for a Station

Visit the Automated Weather Data Network (AWDN) home for detailed information on AWDN station location, period of record, data available, and more.

NEW Visit the HPRCC Archive of National Weather Service Surface Observations home for detailed information on NWS station location, period of record, data available, and more.

Note: These sites are not a part of the HPRCC Online System, and following either link will open a new browser window.

Microsoft PowerPoint - [Real-Time Decisions & Planning] Internet

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File Edit Format Help

NORTHPLATTE NE Lat.(deg)= 41.08 Long.(deg)=100.77 Elev.(m)= 861.

a256079 date/time	T-High F	T-Low F	Rel Hum %	Soil Tmp F@4 in.	Wind Spd mi/hr	Solar langleys	Precip inches	ET-NE inches
1 1 1982 2400	28.573E	12.490E	68.464e	29.754e	6.600e	186.900e	0.000E	0.039
1 2 1982 2400	25.836E	3.769E	68.464e	29.754e	6.600e	186.900e	0.023E	0.038
1 3 1982 2400	27.671E	0.464E	68.464e	29.754e	6.600e	186.900e	0.137E	0.043
1 4 1982 2400	36.225E	9.787E	68.464e	29.754e	6.600e	186.900e	0.000E	0.052
1 5 1982 2400	19.170E	-2.945E	68.464e	29.754e	6.600e	186.900e	0.040E	0.030
1 6 1982 2400	12.735E	-7.767E	68.464e	29.754e	6.600e	186.900e	0.000E	0.024
1 7 1982 2400	30.746E	-1.409E	68.464e	29.754e	6.600e	186.900e	0.000E	0.051
1 8 1982 2400	36.236E	-0.251E	68.464e	29.754e	6.600e	186.900e	0.000E	0.061
1 9 1982 2400	9.790E	-17.657E	68.464e	29.754e	6.600e	186.900e	0.000E	0.022
1 10 1982 2400	6.625E	-15.732E	68.464e	29.754e	6.600e	186.900e	0.002E	0.018
.....								
.....								
.....								
.....								
.....								
10 25 2004 2400	57.128	30.042	60.177	48.090	3.750	276.161	0.000	0.089
10 26 2004 2400	66.830	28.382	74.528	48.188	2.743	293.307	0.000	0.085
10 27 2004 2400	63.176	40.372	98.291	51.996	6.633	61.289	0.000	0.022
10 28 2004 2400	80.258	57.830	63.640	59.553	8.230	265.152	0.000	0.177
10 29 2004 2400	60.566	42.993	58.524	53.701	7.758	220.427	0.000	0.128
10 30 2004 2400	62.798	34.545	46.820	51.131	4.956	289.818	0.000	0.131

Downloaded raw weather data (HPRCC format)

Inputs: weather data

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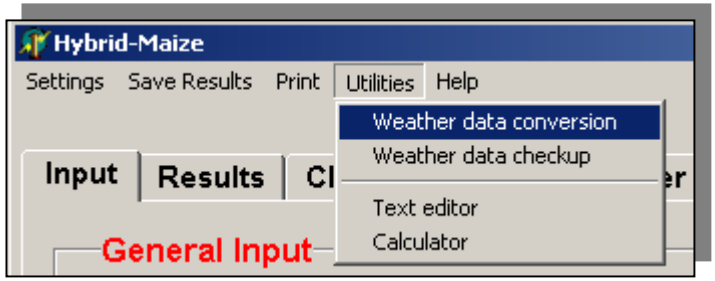

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File Edit Format Help

NORTHPLATTE NE Lat.(deg)= 41.08 Long.(deg)=100.77 Elev.(m)= 861.
41.08 (Lat.)

year	day	Solar MJ/m2	T-High oC	T-Low oC	RelHum %	Rain mm	ET-NE mm	SoilT oC	WndSpd km/hr
1982	1	7.825	-1.9	-10.8	68	0.0	1.0	-1.2	10.6
1982	2	7.825	-3.4	-15.7	68	0.6	1.0	-1.2	10.6
1982	3	7.825	-2.4	-17.5	68	3.5	1.1	-1.2	10.6
1982	4	7.825	2.3	-12.3	68	0.0	1.3	-1.2	10.6
1982	5	7.825	-7.1	-19.4	68	1.0	0.8	-1.2	10.6
1982	6	7.825	-10.7	-22.1	68	0.0	0.6	-1.2	10.6
1982	7	7.825	-0.7	-18.6	68	0.0	1.3	-1.2	10.6
1982	8	7.825	2.4	-17.9	68	0.0	1.5	-1.2	10.6
1982	9	7.825	-12.3	-27.6	68	0.0	0.6	-1.2	10.6
1982	10	7.825	-14.1	-26.5	68	0.1	0.5	-1.2	10.6
.....									
.....									
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.....									
2004	299	11.562	14.0	-1.1	60	0.0	2.3	8.9	6.0
2004	300	12.280	19.3	-2.0	75	0.0	2.2	9.0	4.4
2004	301	2.566	17.3	4.7	98	0.0	0.6	11.1	10.7
2004	302	11.101	26.8	14.4	64	0.0	4.5	15.3	13.2
2004	303	9.229	15.9	6.1	59	0.0	3.3	12.1	12.5
2004	304	12.134	17.1	1.4	47	0.0	3.3	10.6	8.0

Converted weather data (Hybrid-Maize format)

Inputs: weather data

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Predicted by Hybrid-Maize or entered by user

- VE: **Emergence**
- R1: **Silking**, >50% silks are visible outside the husks
- R6: **Physiological maturity** (blacklayer), all kernels on the ear have attained their maximum dry matter accumulation. Average kernel moisture content is 30-35%.
- H: **Harvestable maturity**, after dry-down. Kernel moisture content is below 20%.

Inputs: key growth stages

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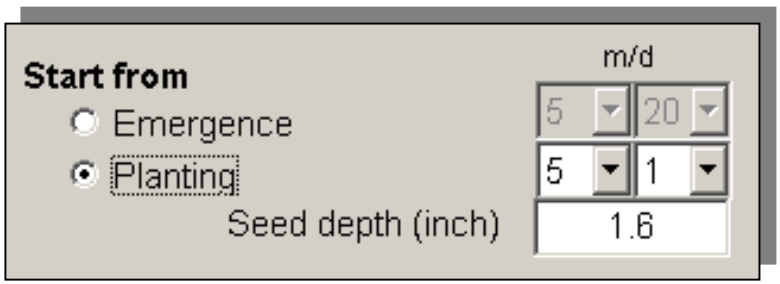
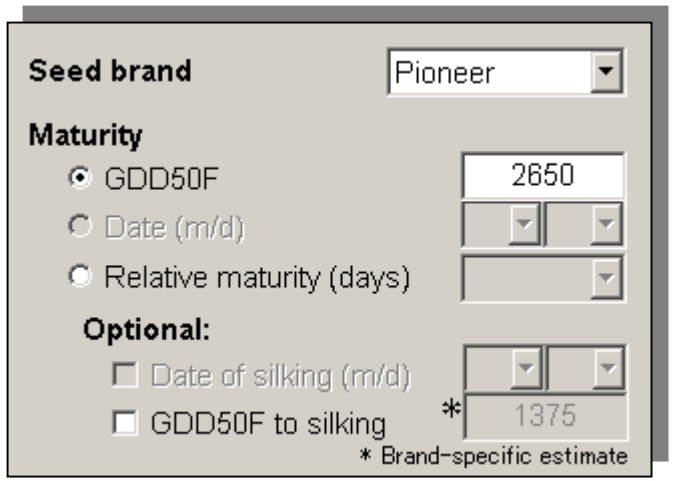
Choices:

- Actual dates of VE, R1, and/or R6 observed
- Model-predicted dates based on hybrid-specific GDD values (GDD to silking and physiol. maturity)
- Model-predicted dates based on brand-specific or generic functions. Inputs can be:
  - GDD to blacklayer (R6), or
  - Crop relative maturity rating (RM)





Inputs: key growth stages

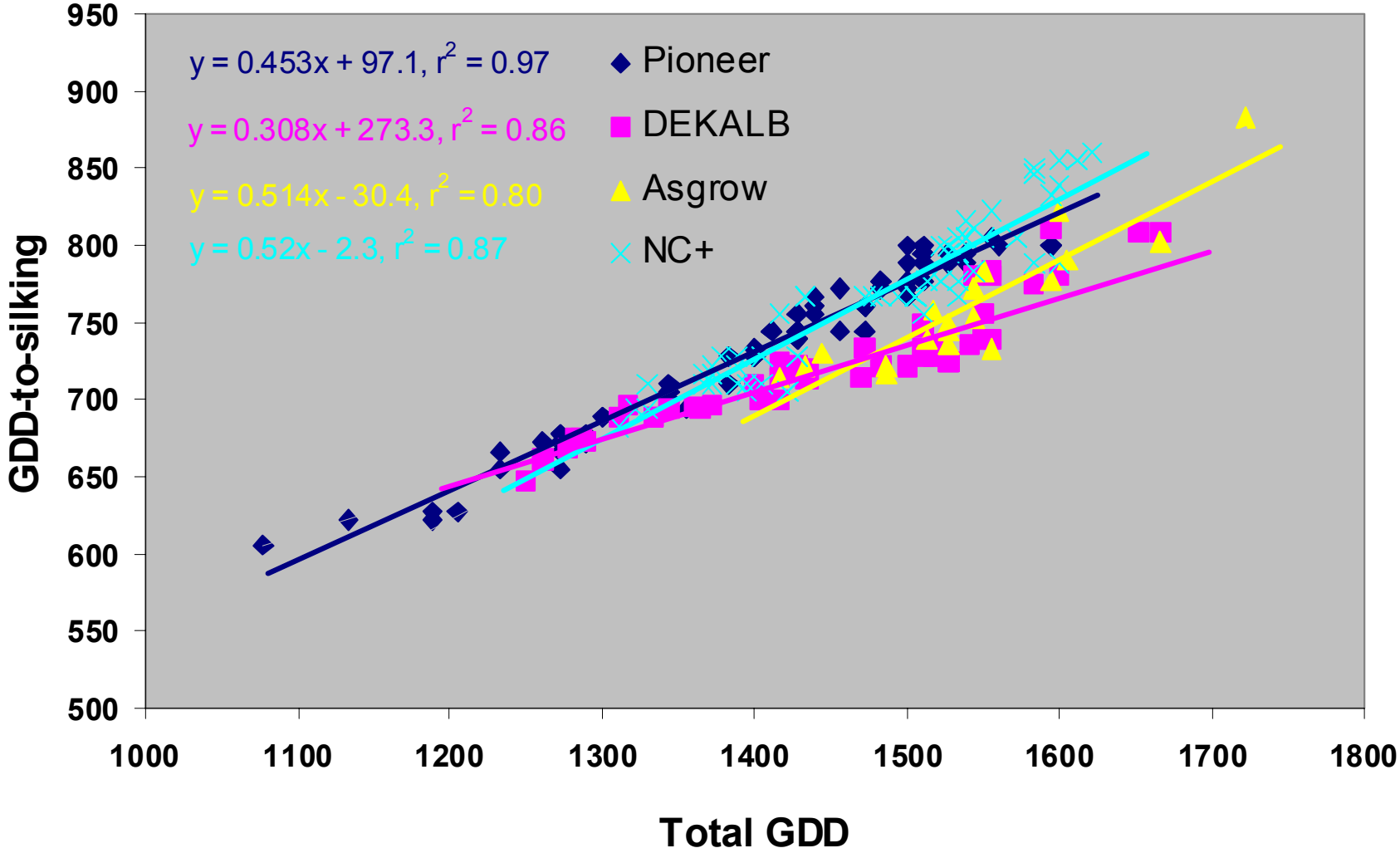


Fig. 4.2. Relationship of GDD-to-silking to total GDD for four commercial maize seed brands. The GDD values refer to ^{o}C.

Inputs: total GDD

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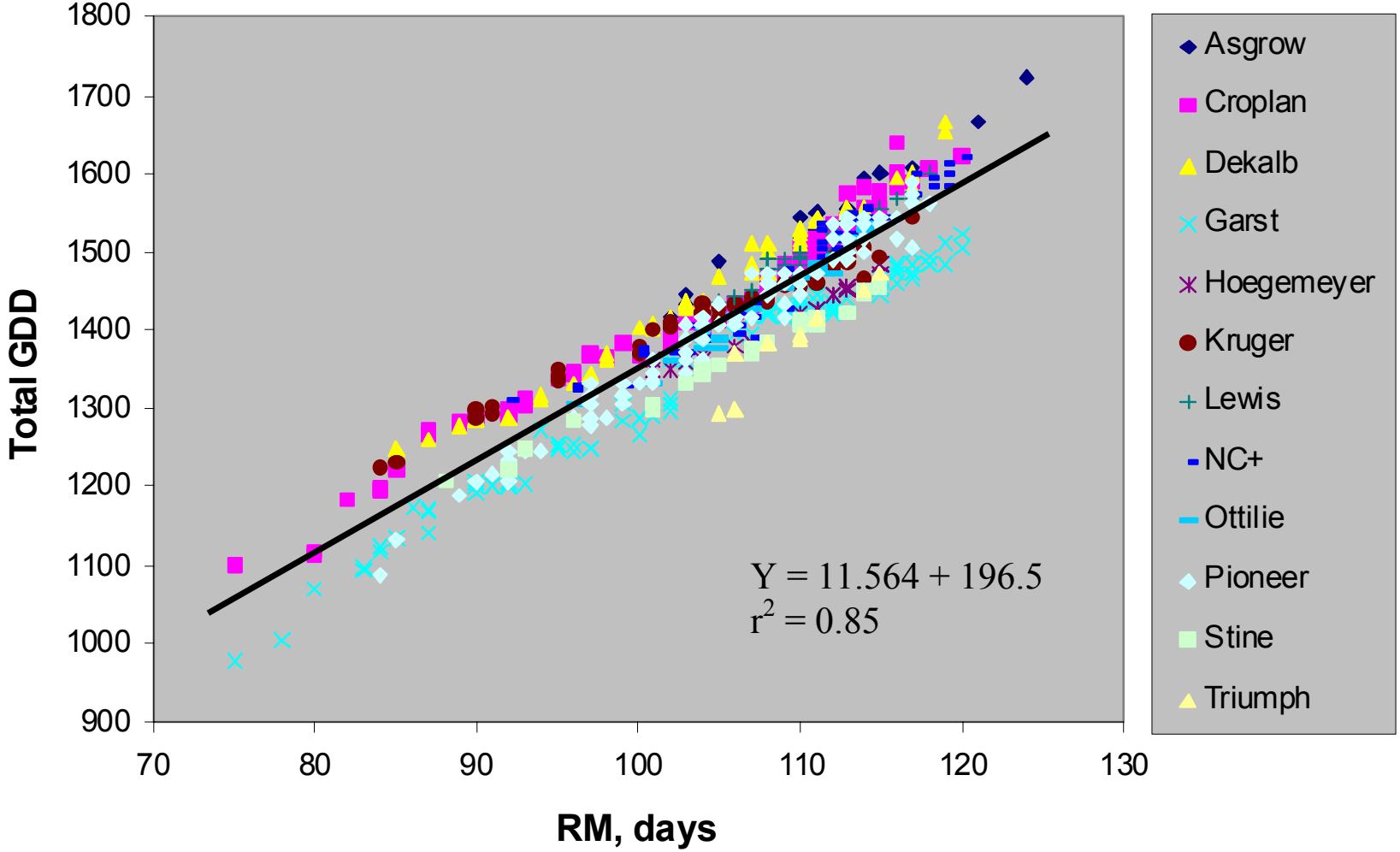

Fig. 4.1. Relationship of total GDD with relative maturity (RM, in days) for 12 commercial maize brands. The black line and the equation represent the regression of the pooled data. The GDD values refer to ^{o}C.

Inputs: relative maturity

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- Yield potential and yield gaps
- Basic structure of Hybrid-Maize
- Model inputs
- Model applications
  - Analyze yield potential and/or water requirements for regional or site-specific decision making (before planting)
  - In-season yield forecasting and decision-making
  - Post-season analysis: what happened?
- Validation, uncertainties & future improvements

Model applications

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Using historical, long-term climate data for a site:

- Assess long-term yield potential and its variation among years (irrigated and non-irrigated).
- Assess change in yield potential due to varying planting date, hybrid choice, plant density, and/or water availability
- Estimate irrigation requirements
- Management decisions:
  - → set adequate yield goals
  - → determine optimal planting date (window)
  - → identify most suitable hybrids
  - → optimal plant density
  - → evaluate economics and risks of various scenarios.

Yield potential analysis

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Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

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Input | Results | Chart | Growth | Weather | Water | Yield trend

General Input

Weather file... North Platte, NE.wth

Years of data available 1982 ~ 2004

Simulation mode

- Current season prediction
  - Include yield trend
- Long-term runs from: 1982
- Single year to: 2004
  - with long-term runs

Start from m/d

- Emergence 5 1
- Planting 5 1

Seed depth (inch) 1.6

Seed brand Pioneer

Maturity

- GDD50F 2650
- Date (m/d)
- Relative maturity (days)

Optional:

- Date of silking (m/d)
- GDD50F to silking * 1375

* Brand-specific estimate

Population (x1000/acre) 32.0

Water

- **Optimal**
  - Estimate irrigation water requirement
- **Rainfed / Irrigated**
  - Assume no water stress in prediction phase

Irrigation schedule

Month	Day	Amount (inch)

Reset entries

Nitrogen

Optimal

Last season residues incorporation

Type

Quantity (Mg/ha)

Date

Soil Nmin at planting (lb/acre)

Soil organic C (%)

Fertilizer N (lb N/acre)

Soil

Top-soil moisture at start, w/w% 25

Max root depth (inch) 39.4

Texture and bulk density (g/cm3)

Top-soil (1 ft) Loam 1.3

Sub-soil Loam 1.4

English units

RUN...

Run	GrainY	GrainDM	StoverDM	TotalDM	HI
1982	241.9	5.73	6.74	12.47	0.46
1983	240.4	5.69	6.72	12.41	0.46
1984	241.8	5.73	7.23	12.95	0.44
1985	174.4	4.13	7.13	11.26	0.37
1986	274.7	6.51	6.11	12.62	0.52
1987	304.4	7.21	6.55	13.76	0.52
1988	246.3	5.83	8.23	14.06	0.41
1989	156.5	3.71	6.68	10.39	0.36
1990	242.9	5.75	7.09	12.84	0.45
1991	233.7	5.53	7.74	13.28	0.42
1992	228.0	5.40	6.26	11.66	0.46
1993	202.2	4.79	5.83	10.62	0.45
1994	260.8	6.18	6.18	12.36	0.50
1995	195.6	4.63	6.70	11.33	0.41
1996	288.6	6.83	5.57	12.41	0.55
1997	249.2	5.90	5.77	11.67	0.51
1998	197.9	4.69	8.11	12.80	0.37
1999	289.0	6.84	5.68	12.52	0.55
2000	207.6	4.92	8.10	13.02	0.38
2001	238.7	5.65	7.14	12.79	0.44
2002	223.0	5.28	6.67	11.95	0.44
2003	241.6	5.72	7.80	13.52	0.42
2004	298.8	7.08	6.49	13.57	0.52

Outputs: results for each year

	Run	GrainY	GrainDM	StoverDM	TotalDM	HI
Best	**1987**	**304.4**	**7.21**	**6.55**	**13.76**	**0.52**
	2004	298.8	7.08	6.49	13.57	0.52
	1999	289.0	6.84	5.68	12.52	0.55
	1996	288.6	6.83	5.57	12.41	0.55
	1986	274.7	6.51	6.11	12.62	0.52
75% percentile	**1994**	**260.8**	**6.18**	**6.18**	**12.36**	**0.50**
	1997	249.2	5.90	5.77	11.67	0.51
	1988	246.3	5.83	8.23	14.06	0.41
	1990	242.9	5.75	7.09	12.84	0.45
	1982	241.9	5.73	6.74	12.47	0.46
	1984	241.8	5.73	7.23	12.95	0.44
Median	**2003**	**241.6**	**5.72**	**7.80**	**13.52**	**0.42**
	1983	240.4	5.69	6.72	12.41	0.46
	2001	238.7	5.65	7.14	12.79	0.44
	1991	233.7	5.53	7.74	13.28	0.42
	1992	228.0	5.40	6.26	11.66	0.46
25% percentile	**2002**	**223.0**	**5.28**	**6.67**	**11.95**	**0.44**
	2000	207.6	4.92	8.10	13.02	0.38
	1993	202.2	4.79	5.83	10.62	0.45
	1998	197.9	4.69	8.11	12.80	0.37
	1995	195.6	4.63	6.70	11.33	0.41
	1985	174.4	4.13	7.13	11.26	0.37
Worst	**1989**	**156.5**	**3.71**	**6.68**	**10.39**	**0.36**
Long-term mean		**238.2**	**5.64**	**6.81**	**12.45**	**0.45**
CV%		16.0	16.0	11.7	7.7	12.6

Outputs: yield-based ranking of results

University of Nebraska Lincoln

Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather

- Individual run
- Across-run summary

Allow editing

Open result in Excel/QPW

Simulations using long-term historical weather data from 1982 to 2004

Rank	Year	Gr.Y	Gr.DM	Stover	tDM	HI	vDays	rDays	V+R	tSola	Tmin	Tmax	Tmean	vTmean	rTr
Best yield	1987	304.4	7.21	6.55	13.76	0.52	71	76	147	77612	52.4	83.1	67.7	68.5	67.
75% percentile	1994	260.8	6.18	6.18	12.36	0.50	66	62	128	67297	56.2	84.3	70.2	69.8	70.
Median yield	2003	241.6	5.72	7.80	13.52	0.42	69	59	128	68538	55.5	84.6	70.1	69.1	71.
25% percentile	2002	223.0	5.28	6.67	11.95	0.44	61	48	109	61870	59.1	87.9	73.5	71.6	75.
Worst yield	1989	156.5	3.71	6.68	10.39	0.36	79	46	125	64013	52.1	81.6	66.9	66.7	67.
Long-term mean		238.2	5.64	6.81	12.45	0.45	73	65	138	69741	54.1	82.3	68.2	68.2	68.
Long-term CV, %		16	16	12	8	13	9	21	13	8	5	4	4	2	7

Among the five years above, frost damage during grain filling occurred in:
1989

Overall probability of frost occurrence during grain filling (%) : 39

Note:
The ranking is based on GRAIN yield.
Gr.Y is grain yield in bu/acre at 15.5% moisture content, Gr.DM, Stover and tDM are dry matter for grain, stover and total abovegroud biomass in short ton/acre.
The long-term means are the numerical averages of all years.

Abbreviations:
HI : harvest index, i.e., the ratio of grain dry matter to total aboveground dry matter
vDays : days from emergence to silking (i.e., vegetative phase)
rDays : days from silking to maturity (i.e., reproductive phase)
V+R : days from emergence to maturity
tSola : total solar radiation from emergence to maturity (Langley)
tRain : total rainfall from emergence to maturity (inch)
Tmin, Tmax, Tmean and ETref : mean daily Tmin, Tmax, Tmean, and ET-reference, respectively, from emergence to maturity (F)
vTmean, rTmean : mean daily Tmean from emergence to silking (i.e., vegetative phase) and from silking to maturity (i.e., reproductive phase), respectively (F)

User-specified inputs:
Weather file : North Platte, NE.wth

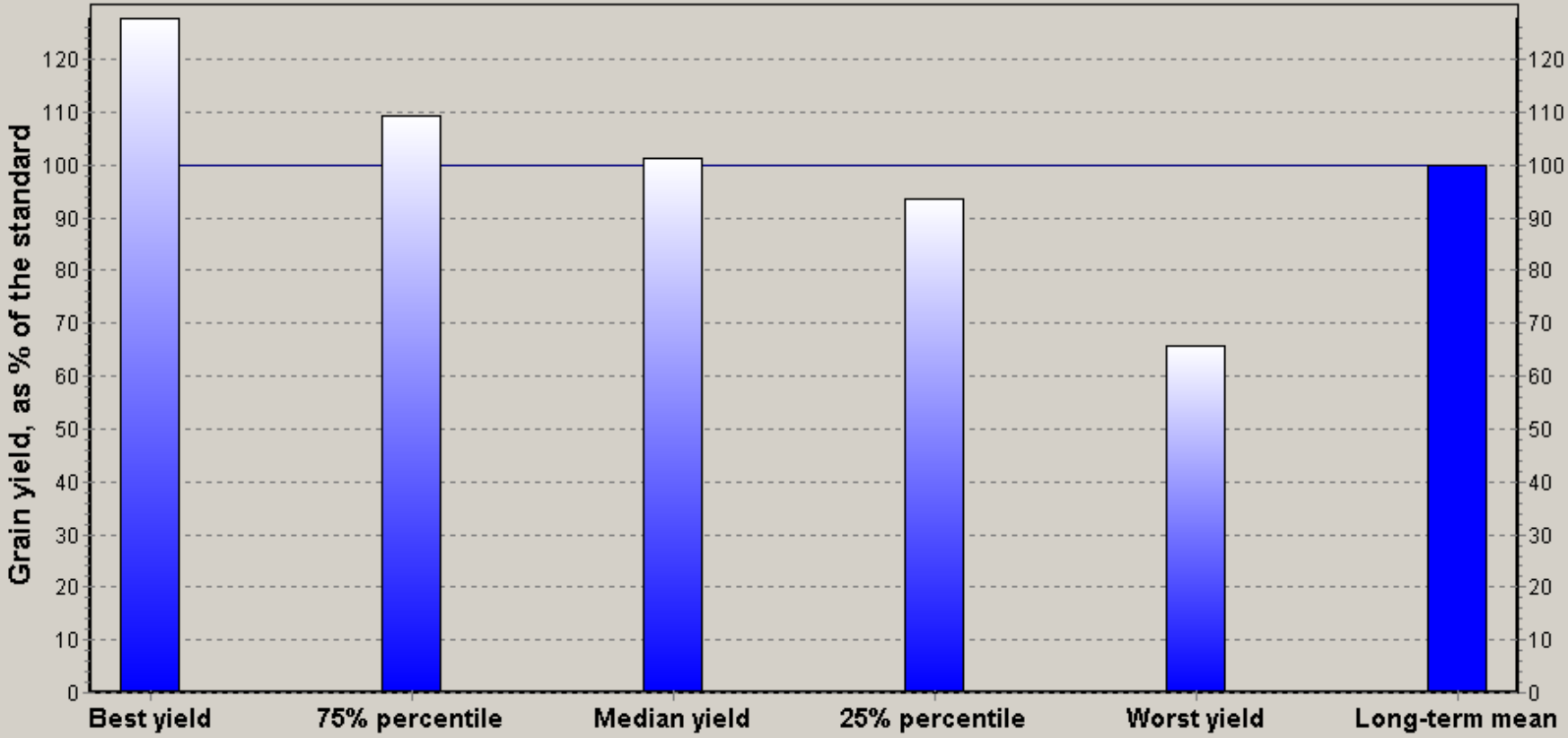
Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather



Scale

- Absolute
- Relative

Rotate the standard (uniform

Options

- Grain yield at 15.5% m.c.
- Grain dry matter
- Stover dry matter
- Aerial dry matter
- Harvest index
- Days before silking
- Days after silking
- Total duration
- Total radiation
- Mean season Tmin
- Mean season Tmax
- Mean season Tmean
- Mean Tmean before silking
- Mean Tmean after silking
- Mean ET-reference
- Total rainfall
- Irrigation (req/actual)

Hybrid-Maize

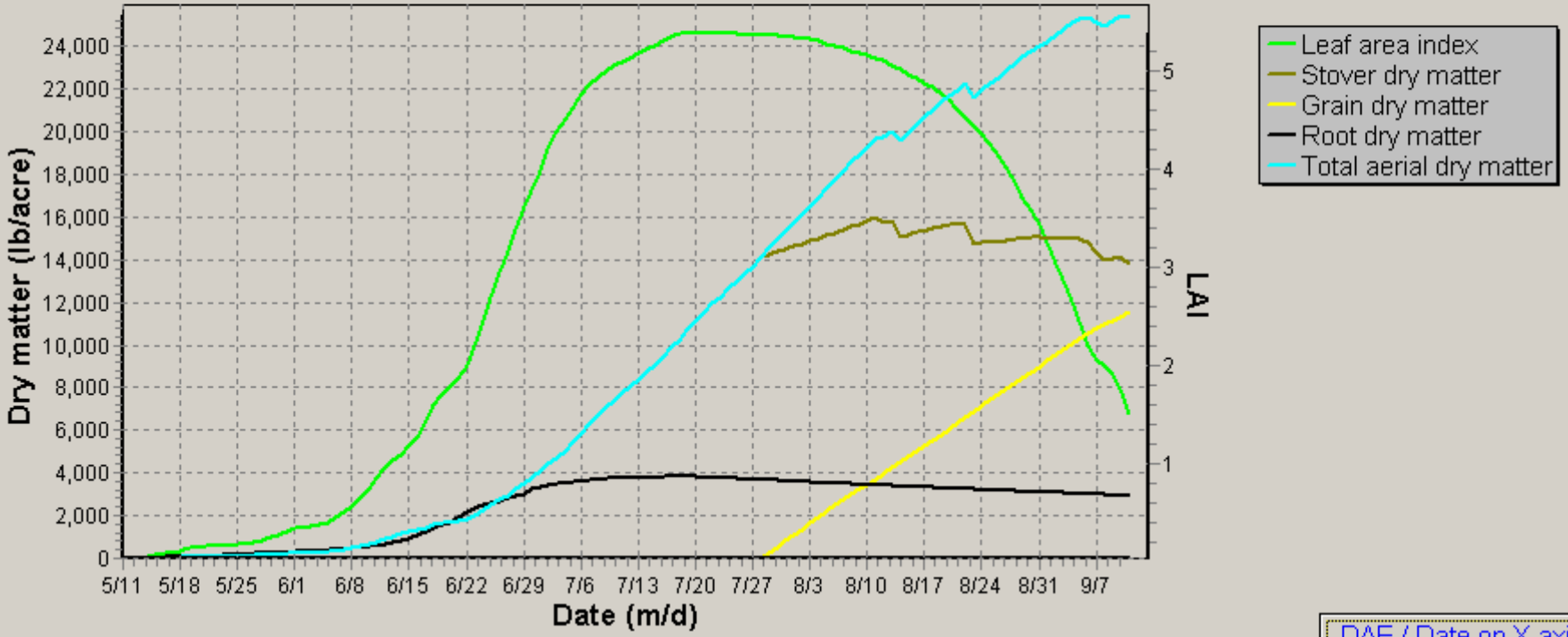
Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather

Growth Dynamics - Emergence to Maturity



DAE / Date on X-axis

- [x] Leaf area index
- [x] Stover dry matter
- [x] Grain dry matter
- [x] Total aerial dry matter
- [x] Root dry matter
- [ ] Gross assimilation
- [ ] Total respiration
- [ ] GDD50F

Individual run

Median yield

Across runs

- [x] Best yield
- [ ] 75% percentile
- [x] Median yield
- [ ] 25% percentile
- [x] Worst yield

Hybrid-Maize

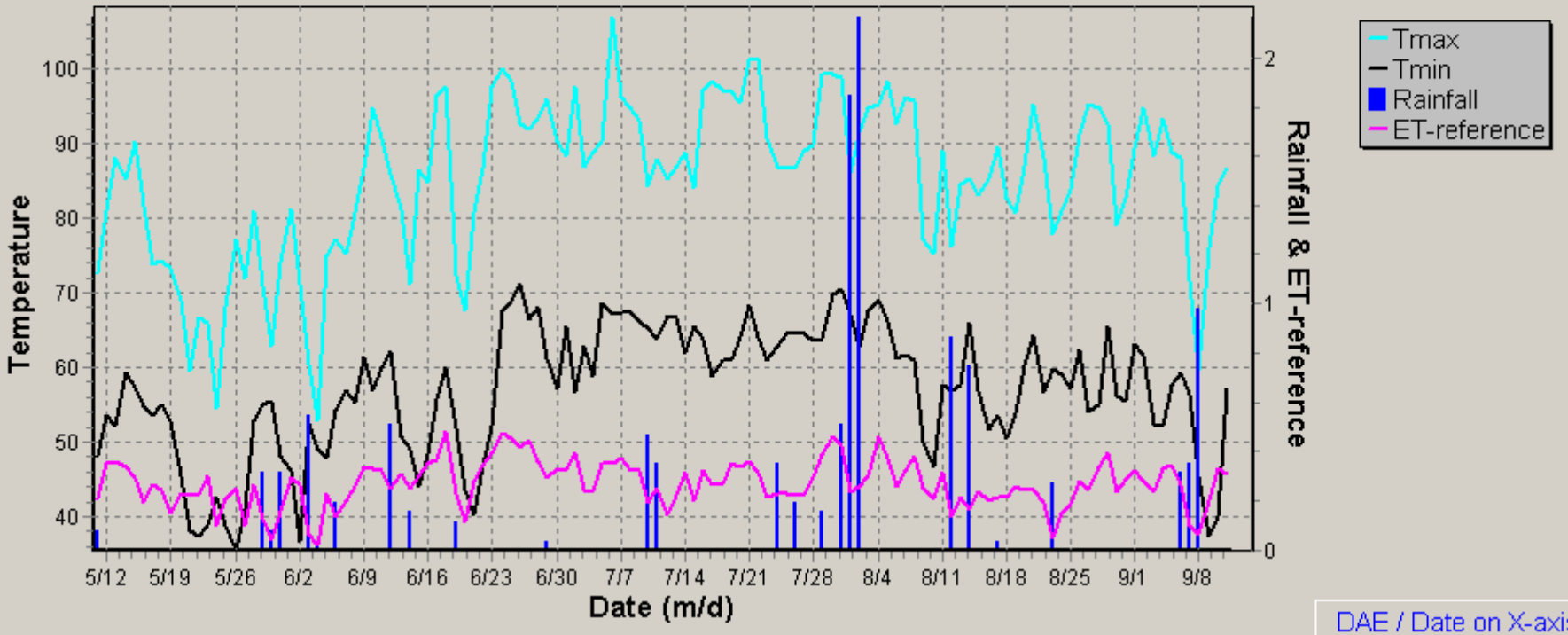
Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather

Weather Analysis - Emergence to Maturity



DAE / Date on X-axis

Seasonal weather statistics:

	Before silki...	After silk...	Season
Mean Tmax (F)	82.7	88.2	85.1
Mean Tmin (F)	55.2	59.0	56.9
Total Rainfall (in...	3.2	8.8	12.0
Mean ET-refere...	0.27	0.27	0.27

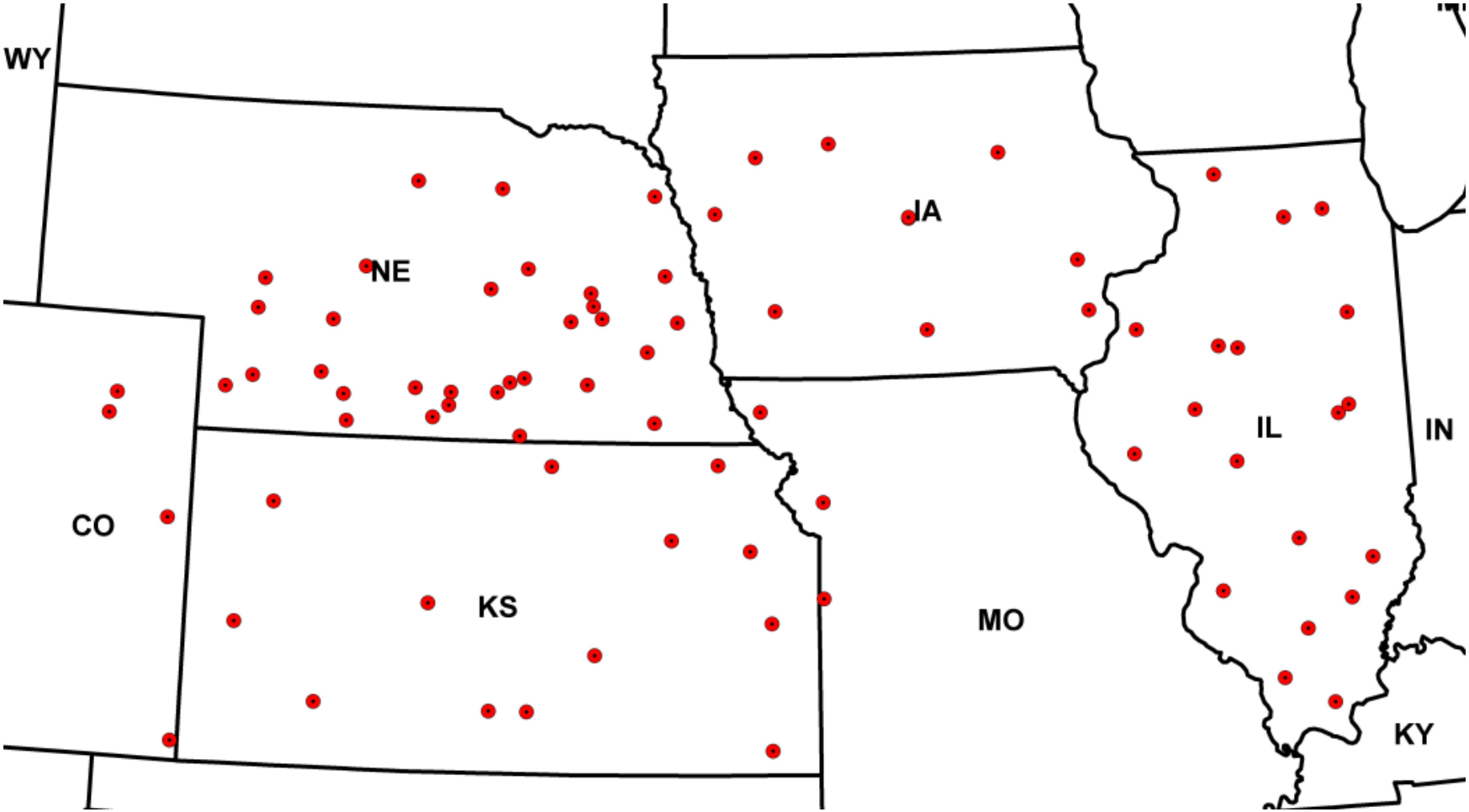
- [ ] Solar radiation (Langley)
- [x] Tmax (F)
- [x] Tmin (F)
- [ ] Tmean (F)
- [ ] Rel. Humidity (%)
- [x] Rainfall (inch)
- [x] ET-reference (inch)

Individual run

Median yield

Across runs

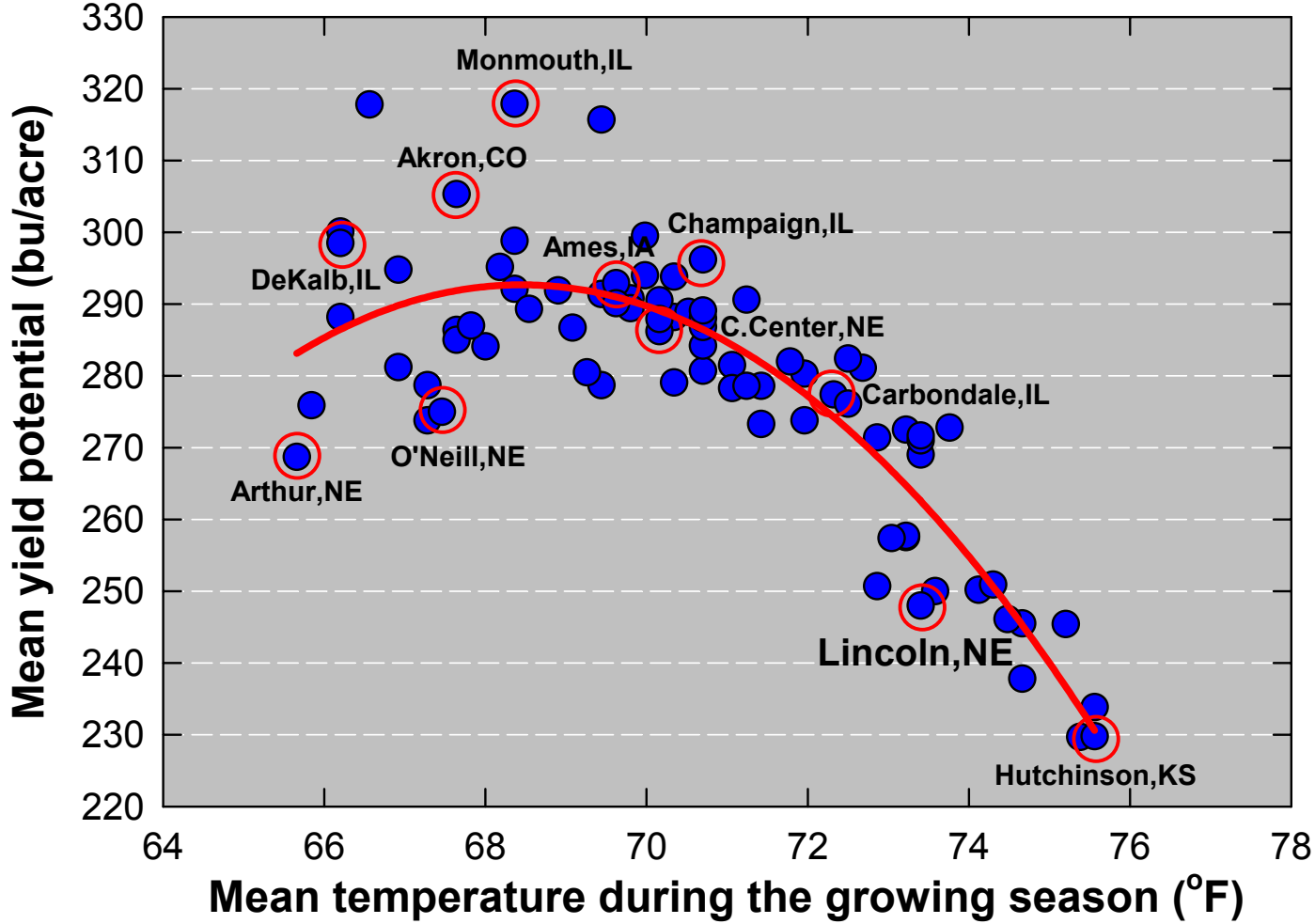
- [x] Best yield
- [x] 75% percentile
- [x] Median yield
- [x] 25% percentile
- [x] Worst yield



80 locations within Lat 32.7-42.7 N; Long 88-102 W; Elev. 130 – 1390 m
Hybrid-Maize simulated yield potential for corn:
Hybrid: 2650 GDU (110 d CRM); Planting date: May 1, 40,000 plants/acre
Management: no limitations by water or nutrients

Corn yield potential in the Corn Belt

University of Nebraska Lincoln



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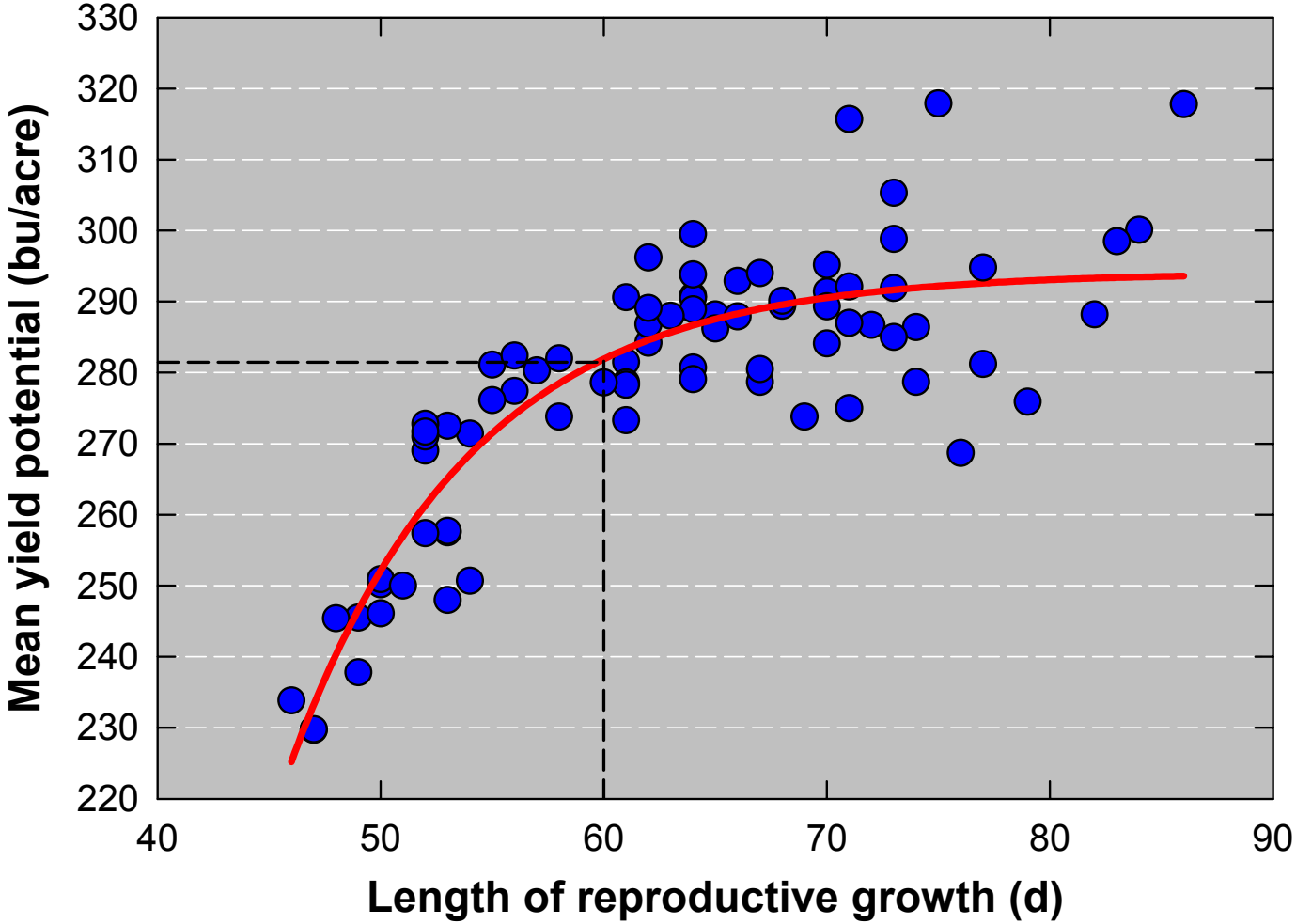
University of Nebraska Lincoln



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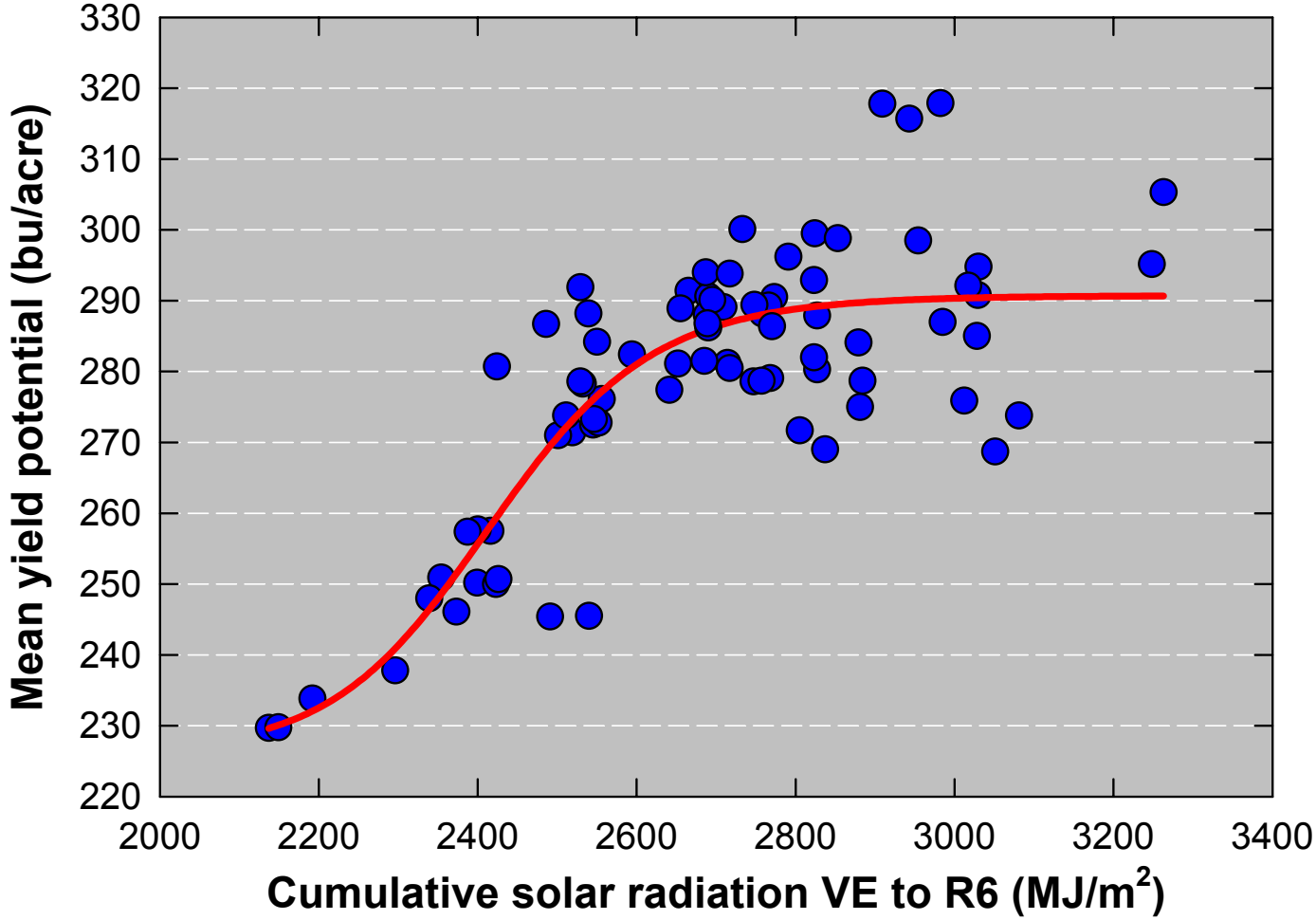
Corn yield potential in the Corn Belt

University of Nebraska Lincoln



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Hybrid-Maize simulated yield potential for corn:
Hybrid: 2650 GDU (110 d CRM); Planting date: May 1, 40,000 plants/acre
Management: no limitations by water or nutrients

Corn yield potential in the Corn Belt

University of Nebraska Lincoln

Yield potential of >280 bu/acre:

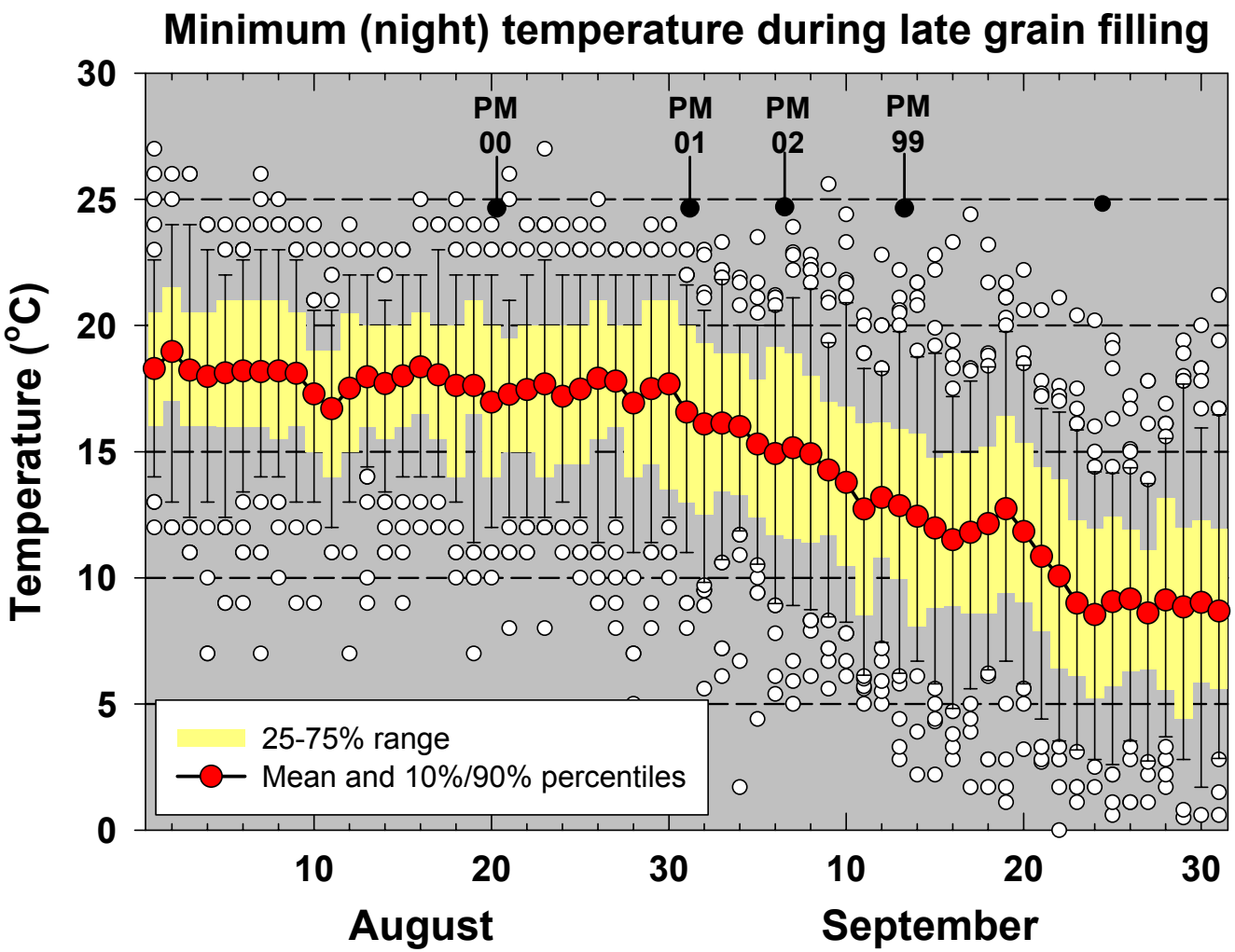
- Long growing season & high solar radiation (>2500 MJ/m^2 from emergence to maturity)
- Cool environment (mean air T <73 F from emergence to maturity)
- Warm during vegetative growth (large veg. biomass) & cool during grain filling (>60 days grain filling period)
- High plant density (varies by hybrid: 30-40k/acre)

Site	Lat	Long	Elev.	Yield potential (bu/ac)			Frost	Mean T	Rainfall	Radiation	Repr.
	N	W	m	Mean	Max	Min	%	F	in	MJ/m^2	Days
Arthur,NE	41.4	101.3	1097	**269**	360	171	91	65.7	10.6	3051	76
O'Neill,NE	42.3	98.5	625	**275**	346	183	60	67.5	12.8	2881	71
Akron,CO	40.1	103.1	1384	**305**	409	197	55	67.6	10.9	3263	73
Monmouth,IL	40.9	90.7	229	**318**	360	291	14	68.4	13.9	2982	75
Ames,IA	42.0	93.5	309	**287**	347	226	16	69.1	20.2	2486	72
Clay Center, NE	40.6	98.1	552	**286**	336	218	17	70.2	16.1	2690	65
Champaign, IL	40.1	88.2	229	**291**	335	251	0	71.2	17.3	2690	61
Carbondale,IL	37.7	89.2	137	**277**	366	236	0	72.3	13.1	2641	56
Lincoln, NE	40.8	96.7	357	**248**	291	213	0	73.4	12.7	2339	53
Hutchinson,KS	37.6	98.0	477	**230**	265	192	0	75.6	11.8	2149	47

Hybrid-Maize simulated yield potential for corn:
Hybrid: 2650 GDU (110 d CRM); Planting date: May 1, 40,000 plants/acre
Management: no limitations by water or nutrients

Yield potential analysis for Lincoln, NE

University of Nebraska Lincoln



Lincoln, NE: At this site, high night temperatures during grain filling may cause early maturity of corn. Delaying planting or choosing a longer season hybrid could move grain filling into a period with lower night temperatures.

Climate data 1948 – 2000.

Yield potential analysis for Lincoln, NE

University of Nebraska Lincoln

Hybrid GDU	Planting date	Yield potential (bu/acre)	Maturity	Emerg. to silking days	Emerg. to silking avg. T (F)	Silking to maturity days	Silking to maturity avg. T (F)	Risk of frost (%)
2650	April 25	**248**	late Aug	64	70	52	77	0
2650	May 15	**255**	early Sep	56	73	55	75	0
2850	April 25	**276**	early Sep	67	71	59	76	0
2850	May 15	**285**	late Sep	59	73	63	74	11

- Average yield potential simulated with the Hybrid-Maize model
- Daily climate data 1986-2004 (T, radiation, rainfall, humidity)
- Hybrids: 2650 GDD = 110 d CRM; 2850 GDD = 119 d CRM
- 40,000 plants/acre, full irrigation, optimal management

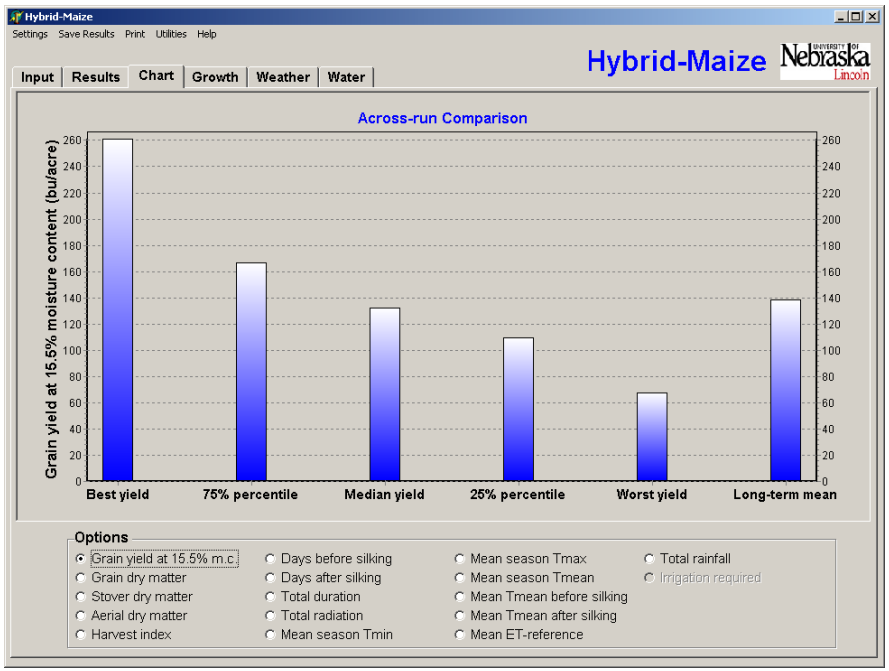
Yield potential analysis for Lincoln, NE

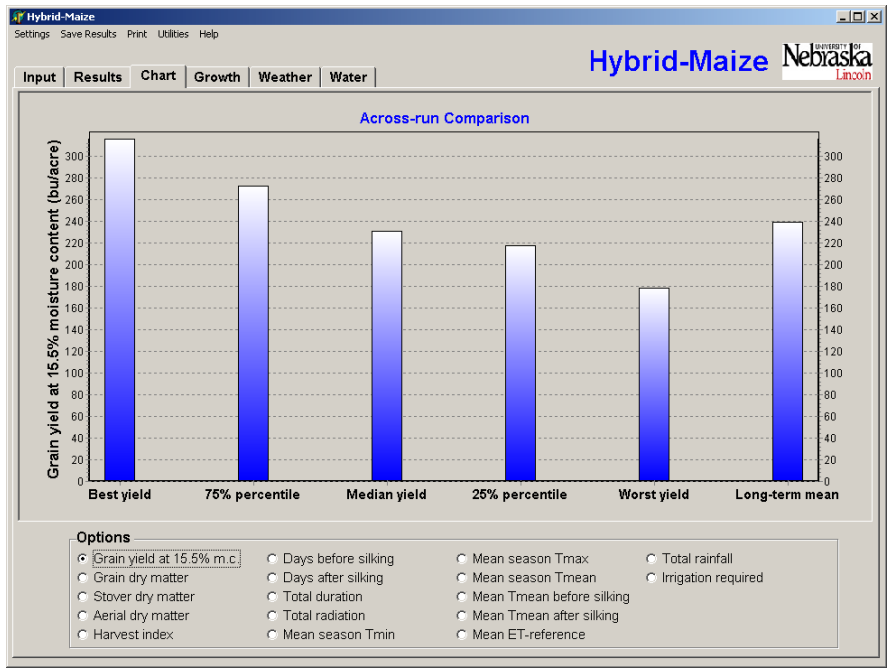
University of Nebraska Lincoln

Site: **Champion**, southwest NE (semi-arid)
Climate data: 1982 to 2004
Variable rainfall, <4 to >20” during the growing season
Planting: Hybrid with GDD 2650, planted on May 1 @ 30,000/acre
Soil: Loam, topsoil moisture at planting 25 vol.%, deep (>40”)

Dryland corn yield potential
Average: 138 bu/a
Range: 68-261 bu/a

Irrigated corn yield potential
Average: 239 bu/a
Range: 178-316 bu/a





Analysis of water requirements

University of Nebraska Lincoln

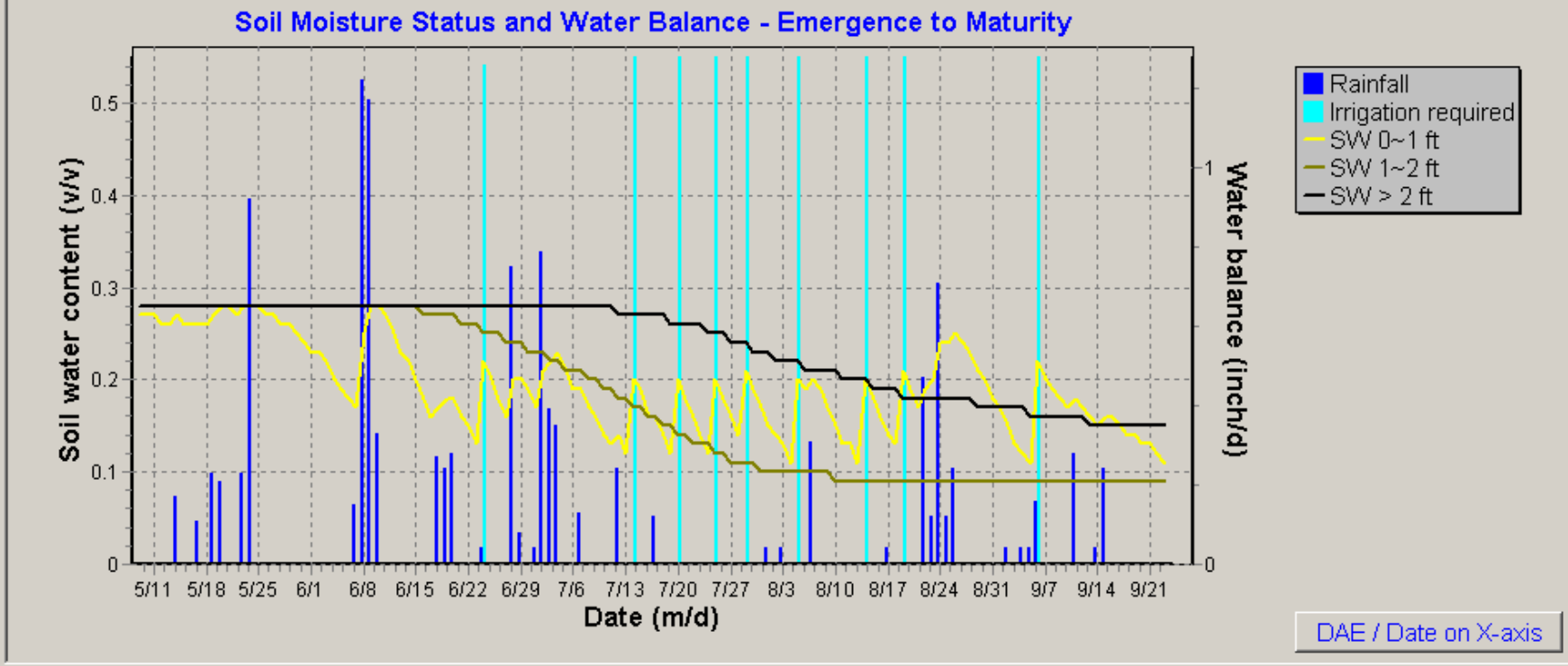
Hybrid-Maize

Settings Save Results Print Utilities Help

Input | Results | Chart | Growth | Weather | Water

Hybrid-Maize

Nebraska Lincoln



- [x] Rainfall (inch)
- [x] Irrigation required (inch)
- [ ] ET-max (inch)
- [ ] ET-actual (inch)
- [x] Soil water 0~1 ft (v/v)
- [x] Soil water 1~2 ft (v/v)
- [x] Soil water > 2 ft (v/v)
- [ ] Water stress coefficient

(•) Individual run

75% percentile

( ) Across runs

- [x] Best yield
- [ ] 75% percentile
- [x] Median yield
- [ ] 25% percentile
- [x] Worst yield

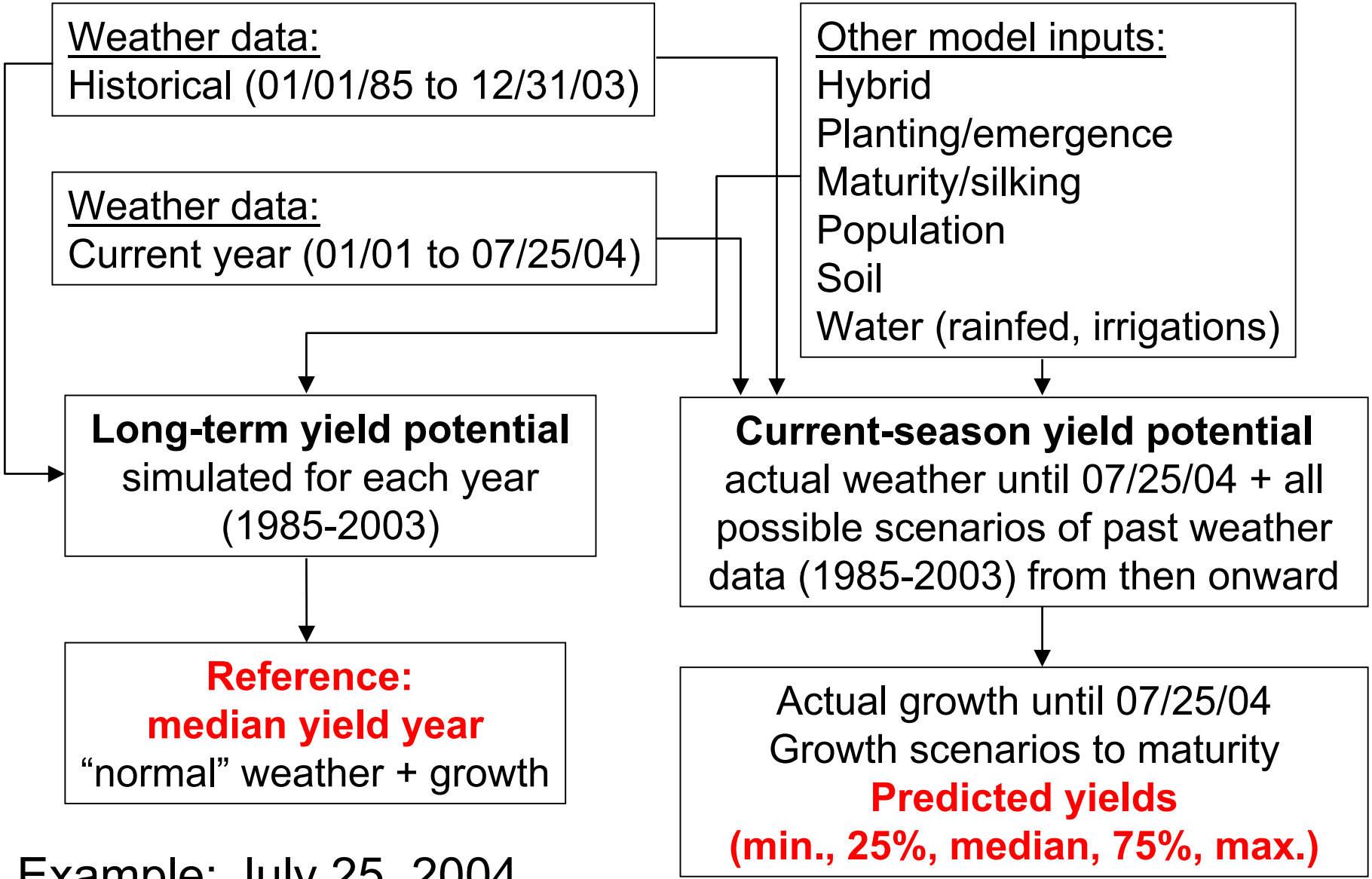
Irrigation required

Average: 12”

Range: 8-15”

Using real-time climate data for a growing season :

- Estimate actual yield potential or water-limited yield potential based on **actual + historical** daily records of solar radiation, temperature, and rainfall.
- Decision aid for:
  - → comparing growth with normal years/other years.
  - → adjusting yield goal and making adjustments in fertilizer amounts (sidedress, fertigation)
  - → evaluating soil moisture and making decisions on irrigation
  - → marketing decisions (farmers)
  - → grain purchasing decisions (feedlots, ethanol plants)
  - → overall corn production forecasts (policy makers, crop insurance, markets, etc.)



Example: July 25, 2004

In-season yield forecasting

University of Nebraska Lincoln

Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather | Water | Yield trend

General Input

Weather file... August08.wth

Years of data available 1986 ~ 2004

Simulation mode

- (•) Current season prediction
  - [x] Include yield trend
- ( ) Long-term runs
- ( ) Single year 2004
  - [ ] with long-term runs

Start from m/d

- ( ) Emergence 5 1
- (•) Planting 5 12

Seed depth (inch) 1.5

Seed brand Pioneer

Maturity

- (•) GDD50F 2870
- ( ) Date (m/d)
- ( ) Relative maturity (days)

Optional:

- [ ] Date of silking (m/d)
- [x] GDD50F to silking 1440

Population (x1000/acre) 30.0

Water

- ( ) **Optimal**
  - [ ] Estimate irrigation water requirement
- (•) **Rainfed / Irrigated**
  - [x] Assume no water stress in prediction phase

Irrigation schedule

Month	Day	Amount (inch)
7	20	1.25
7	29	1
8	2	1.25
8	6	1.25

Reset entries

Nitrogen

Optimal [x]

Last season residues incorporation

Type

Quantity (Mg/ha)

Date

Soil Nmin at planting (lb/acre)

Soil organic C (%)

Fertilizer N (lb N/acre)

Soil

Top-soil moisture at start, w/w% 25

Max root depth (inch) 45

Texture and bulk density (g/cm3)

Top-soil (1 ft) Silt loam 1.3

Sub-soil Silt loam 1.4

English units

RUN...

Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather | Water | Yield trend

Growth Dynamics - Emergence to Maturity

Total aboveground DM (lb/acre)

24,000
22,000
20,000
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0

6/3 6/18 7/3 7/18 8/2 8/17 9/1 9/16 10/1

Date (m/d)

- Best yield
- 75% percentile
- Actual/Median yield
- 25% percentile
- Worst yield
- Long-term median
- Mark of start of forecast

DAE / Date on X-axis

- Leaf area index
- Stover dry matter
- Grain dry matter
- Total aerial dry matter
- Root dry matter
- Gross assimilation
- Total respiration
- GDD50F

Individual run

Median yield

Across runs

- [x] Best yield
- [x] 75% percentile
- [x] Median yield
- [x] 25% percentile
- [x] Worst yield
- [x] Long-term median

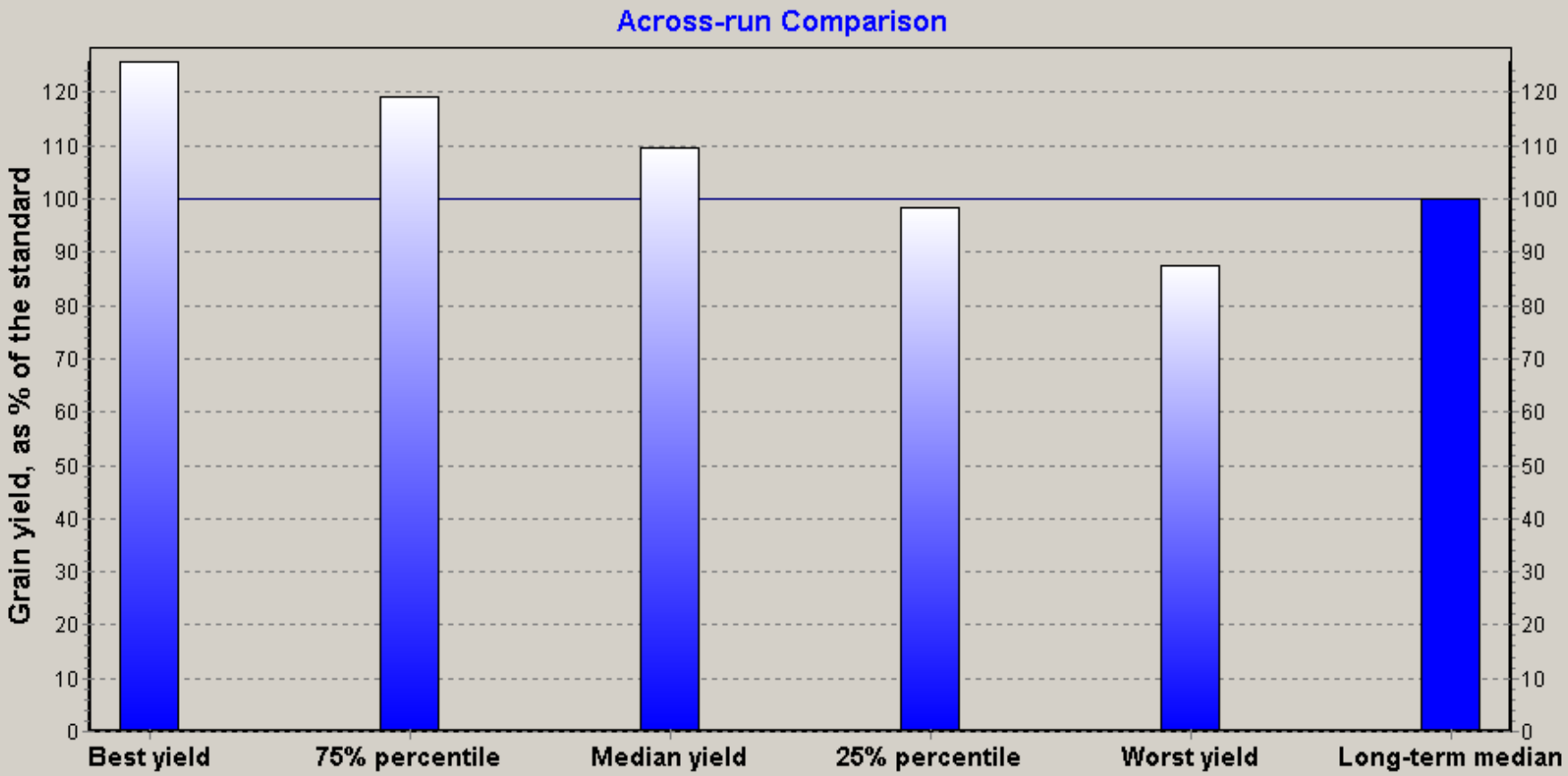
Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather | Water | Yield trend



Scale

- Absolute
- Relative

Rotate the standard (uniform

Options

- Grain yield at 15.5% m.c.
- Grain dry matter
- Stover dry matter
- Aerial dry matter
- Harvest index
- Days before silking
- Days after silking
- Total duration
- Total radiation
- Mean season Tmin
- Mean season Tmax
- Mean season Tmean
- Mean Tmean before silking
- Mean Tmean after silking
- Mean ET-reference
- Total rainfall
- Irrigation (req/actual)

Hybrid-Maize

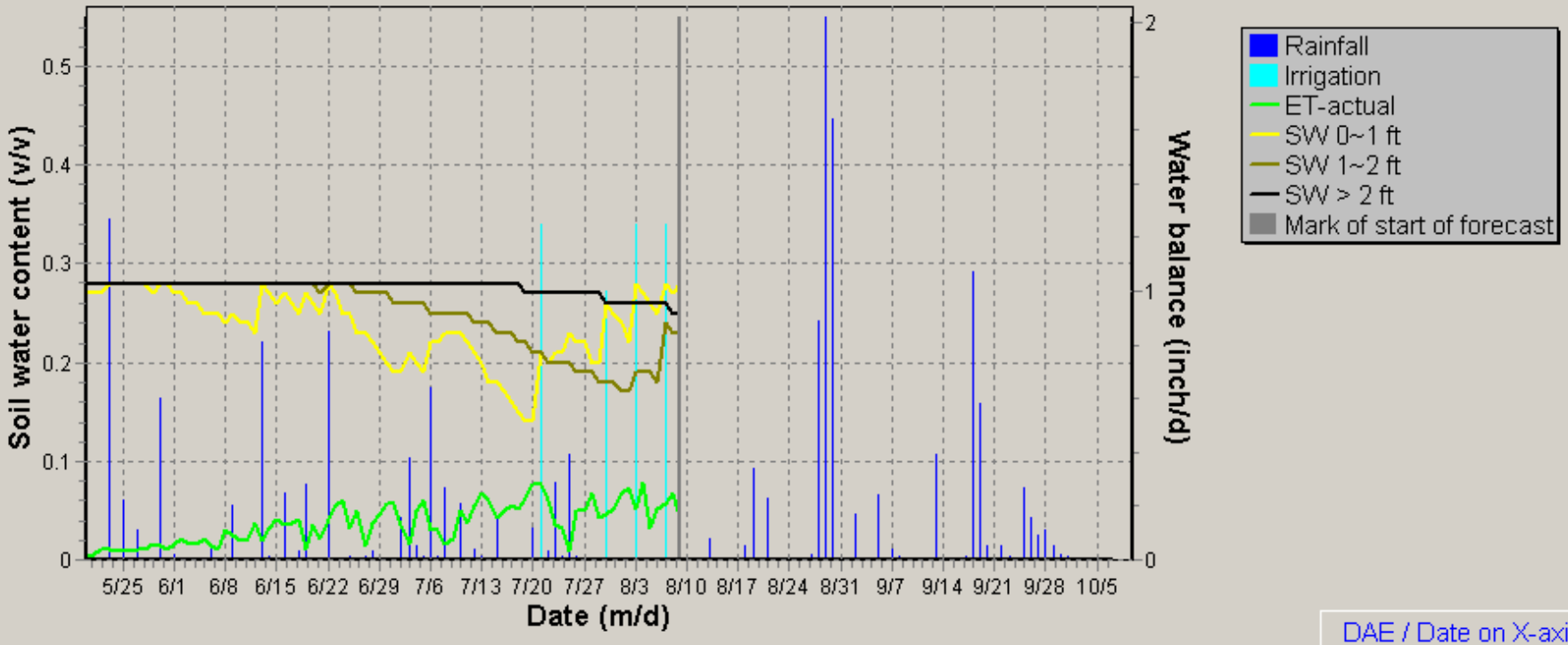
Settings Save Results Print Utilities Help

Hybrid-Maize

University of Nebraska Lincoln

Input | Results | Chart | Growth | Weather | Water | Yield trend

Soil Moisture Status and Water Balance - Emergence to Maturity



DAE / Date on X-axis

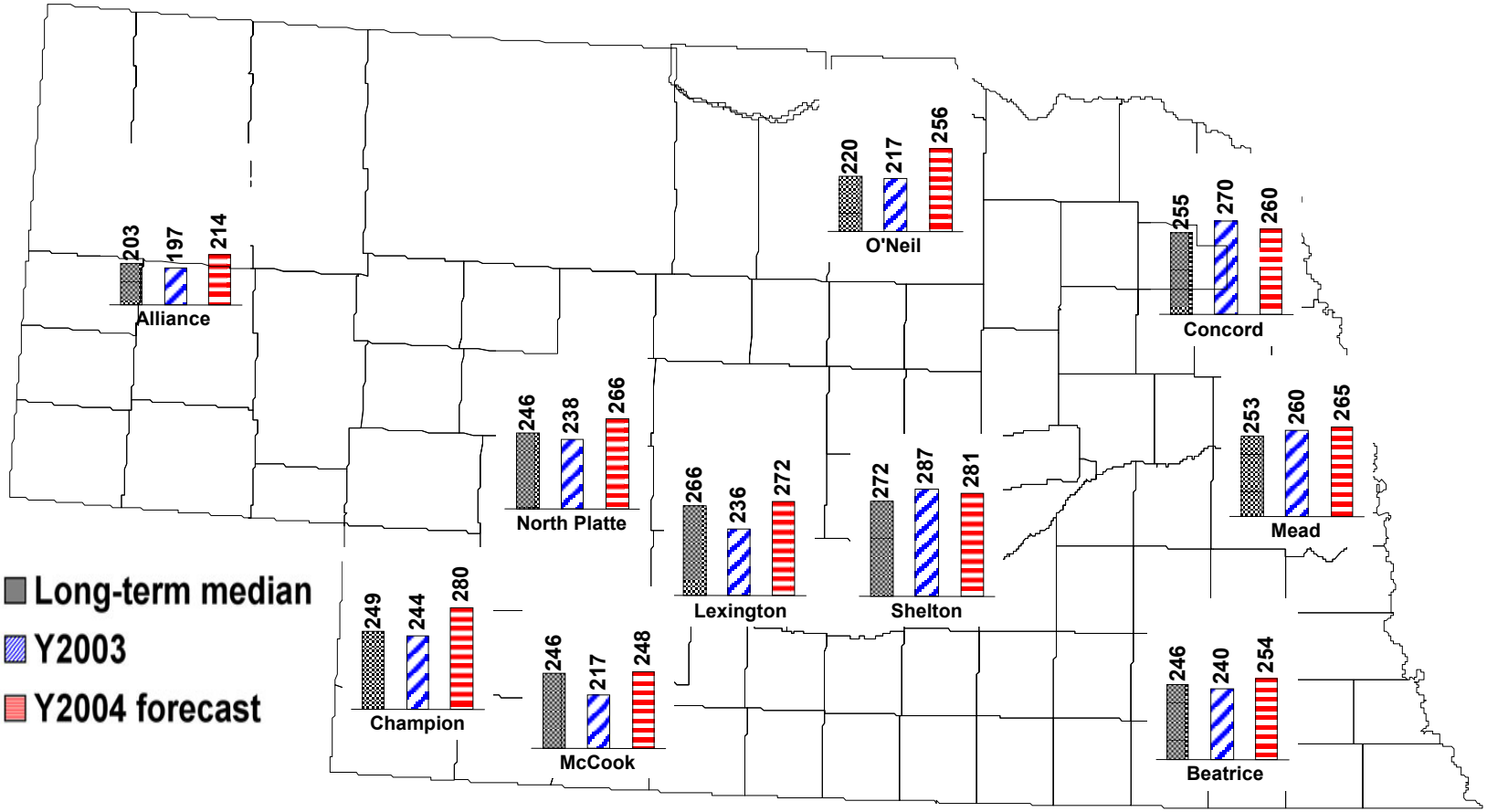
- [x] Rainfall (inch)
- [x] Irrigation (req/actual, inch)
- [ ] ET-max (inch)
- [x] ET-actual (inch)
- [x] Soil water 0~1 ft (v/v)
- [x] Soil water 1~2 ft (v/v)
- [x] Soil water > 2 ft (v/v)
- [ ] Water stress coefficient

Individual run

Median yield

Across runs

- [x] Best yield
- [ ] 75% percentile
- [x] Median yield
- [ ] 25% percentile
- [x] Worst yield
- [x] Long-term median



Irrigated corn in Nebraska: yield potential prediction made on August 03, 2004.

Average predicted yield potential (irrigated, 10 sites)	2003	241 bu/a
	2004	260 bu/a (Aug. 3, +8%)
State average corn yield (dryland + irrigated):	2003	146 bu/a
	2004	166 bu/a (+14%)

In-season yield forecasting

University of Nebraska Lincoln

Hybrid-Maize

Settings Save Results Print Utilities Help

Hybrid-Maize Nebraska Lincoln

Input | Results | Chart | Growth | Weather | Water

General Input

Select weather file... ONeill, NE.wth

Years of data available 1985 ~ 2003

Simulation mode:

- Current season prediction
- Long-term runs
- Single year 2002
  - with long-term runs

Start from: m/d

- Emergence 5 20
- Planting 5 1

Planting depth (inch) 1.4

Maturity:

- GDD50F 2500
- On date

Optional: m/d

- Date of silking
- GDD50F to silking

Population (x1000/acre) 30

Water

- Optimal
  - Estimate irrigation water requirement
- Rainfed / Irrigated
  - Assume no water stress in prediction phase

Irrigation schedule

Month	Day	Amount (inch)
6	30	1.2
7	6	1.2
7	11	1.2
7	17	1.2
7	22	1.2
7	28	1.2
6	22	1.2

Clear entries

Nitrogen

Optimal

Last season residues incorporation

Type

Quantity (Mg/ha)

Date

Soil Nmin at planting (lb/acre)

Soil organic C (%)

Fertilizer N (lb N/acre)

Soil

Top-soil moisture at start, w/w% 25

Max root depth (inch) 50

Texture and bulk density (g/cm3)

Top-soil (1 ft) Loamy sand 1.4

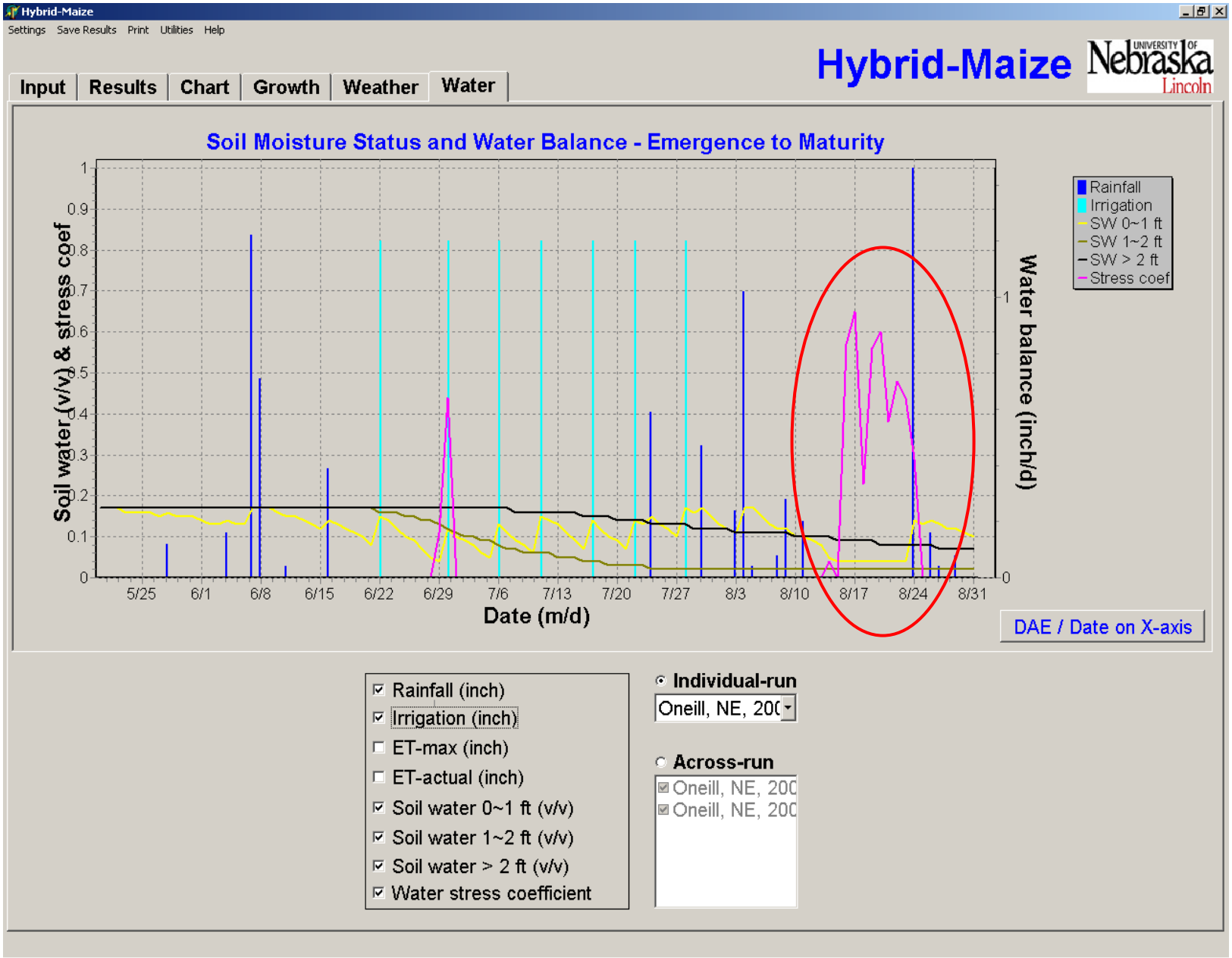
Sub-soil Loamy sand 1.5

English units

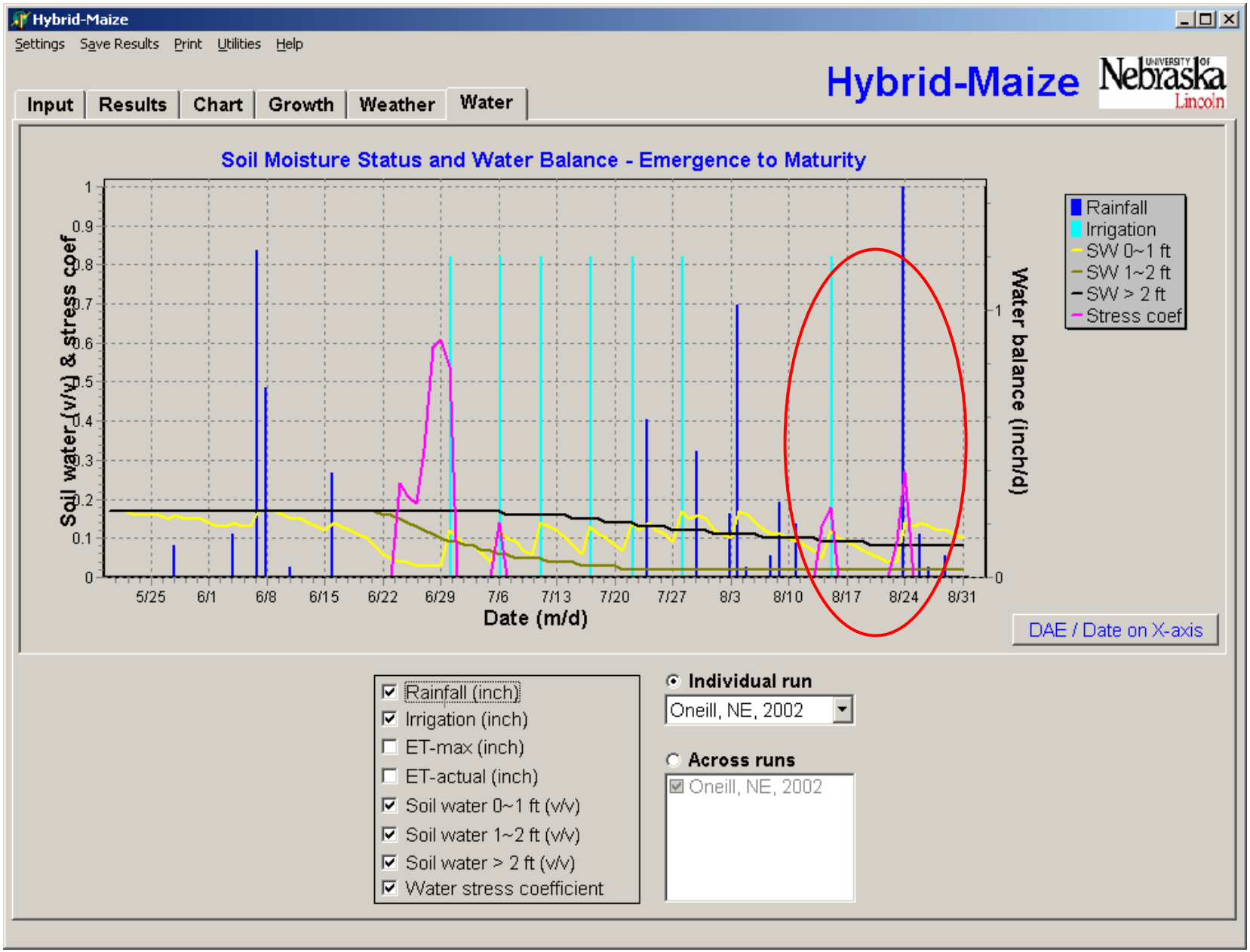
RUN...

Post-season analysis

Nebraska Lincoln



7 irrigations 06/22-07/28, predicted grain yield: 201 bu/acre



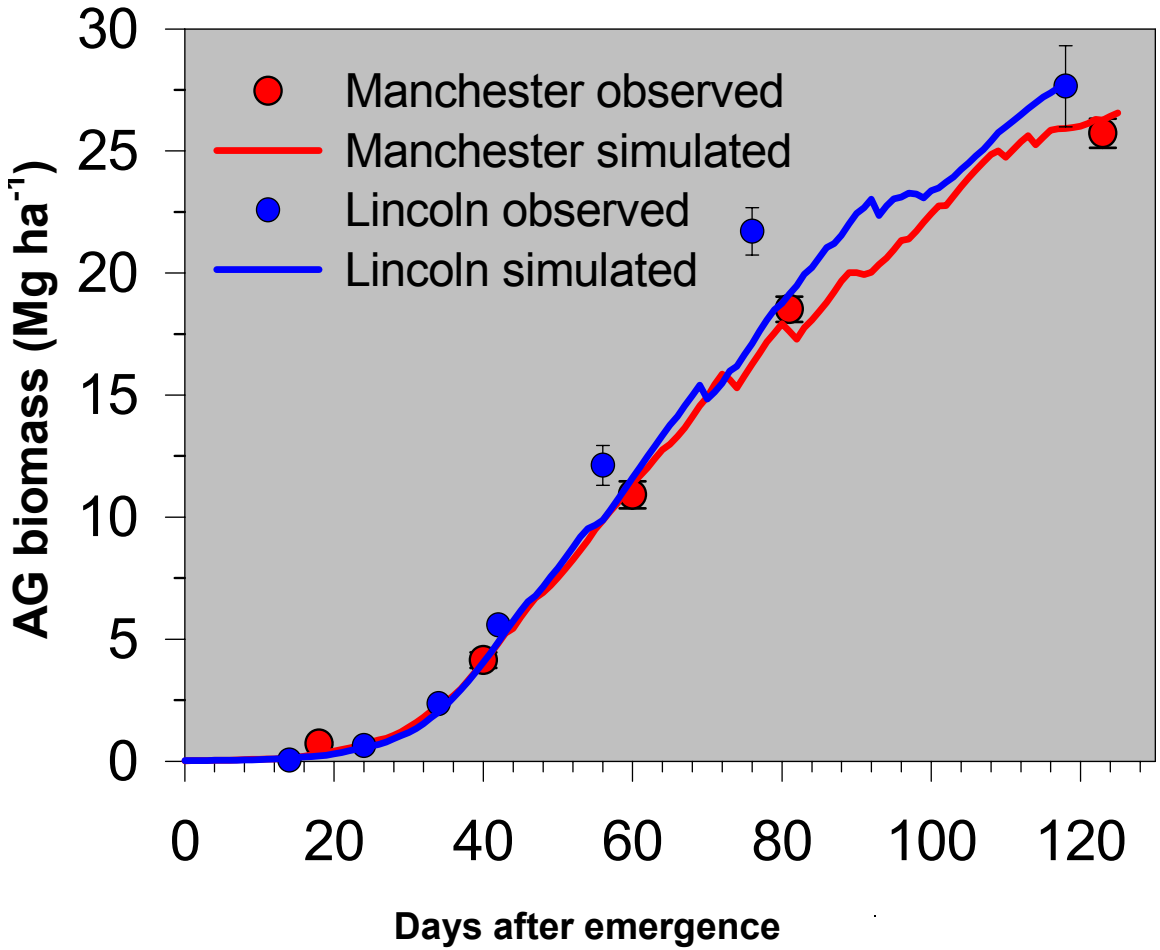
7 irrigations 06/30-08/15, predicted grain yield: 223 bu/acre

Crop model	Grain	Stover	Total biomass	HI
	---------- Mg dry matter/ha ----------			
Measured	13.2	13.2	26.4	0.50
Ceres-Maize	12.4	11.0	23.4	0.53
Muchow-Sinclair	11.4	11.4	22.8	0.50
Intercom	9.7	9.0	18.7	0.52
Hybrid-Maize	13.1	13.2	26.3	0.50

Lincoln, NE, high-yield experiment, corn after soybean, 37,000 plants/acre, intensive nutrient management, averages of 1999-2001.

Validation

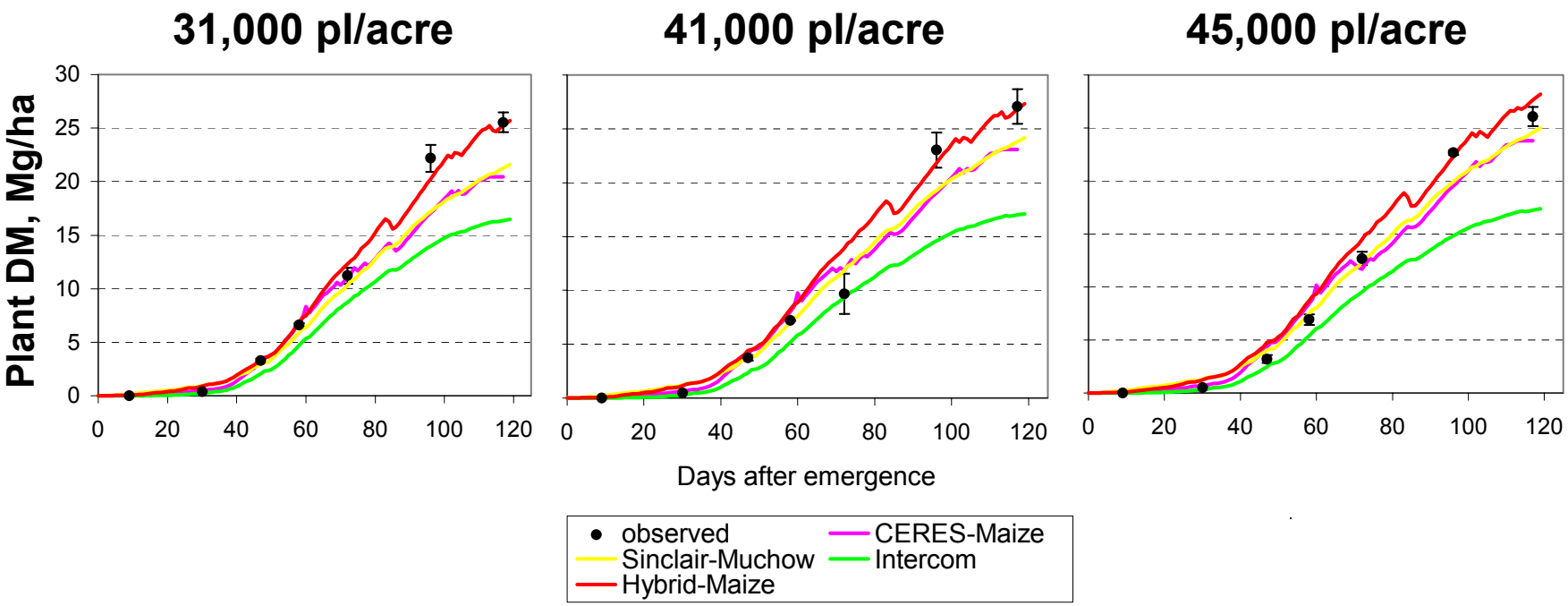
University of Nebraska Lincoln



Total aboveground crop biomass during the growing season.
Manchester: Francis Childs farm, 2002, Pioneer 33P67, 34,000 plants/acre
Lincoln: High-yield experiment, 2002, Pioneer 33P67, 38,000 plants/acre

Validation

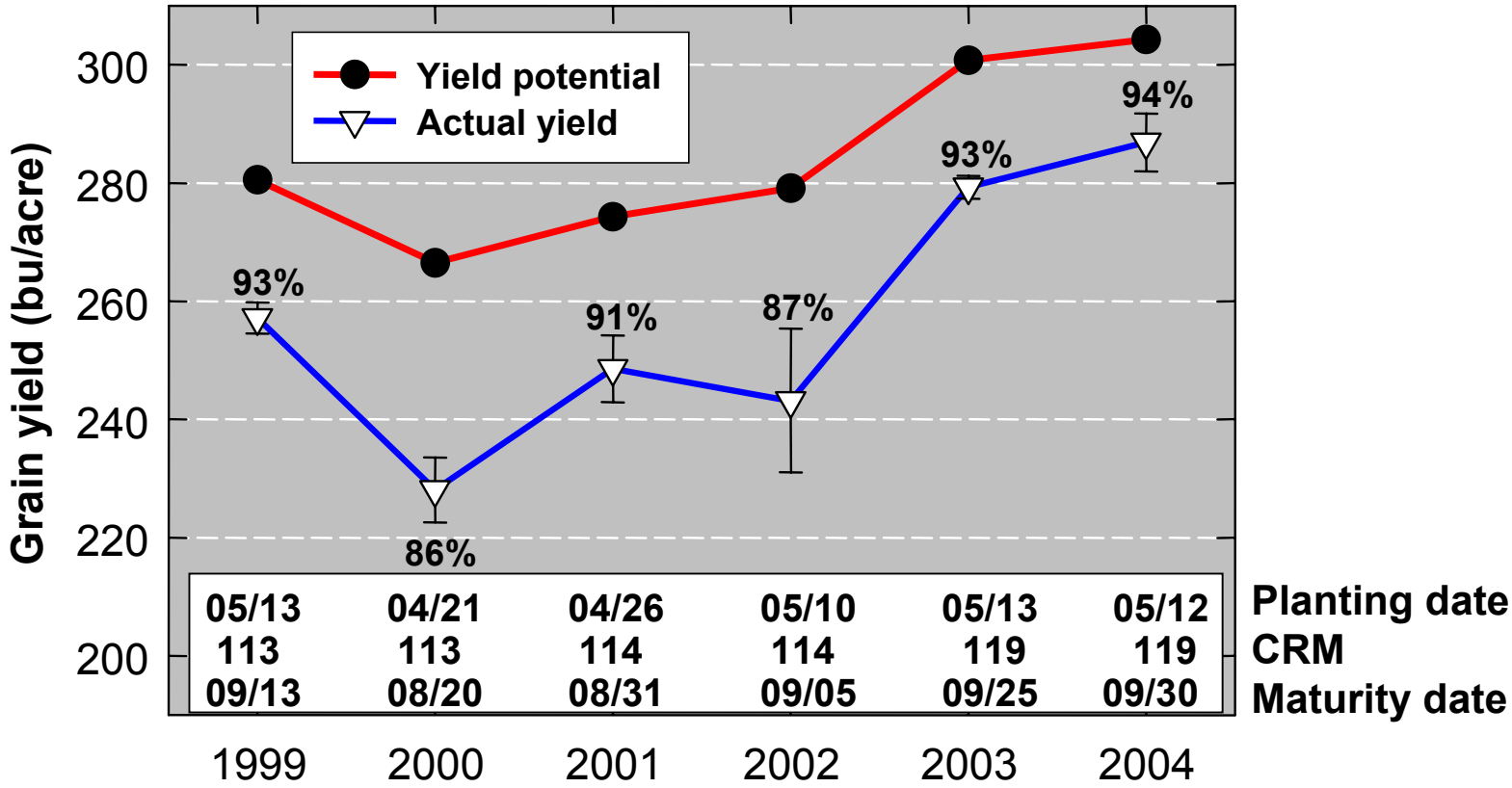
University of Nebraska Lincoln



Lincoln, NE, high-yield experiment, corn following soybean, intensive nutrient management, 2001.

Validation

University of Nebraska Lincoln



Yield potential: simulated with Hybrid-Maize model for actual emergence and maturity dates and final plant stands in each year.
Actual yields: EI experiment, corn following soybean, high plant population (37-43k), intensive nutrient management

Validation: Yield potential at Lincoln, NE

University of Nebraska Lincoln

Hybrid-Maize

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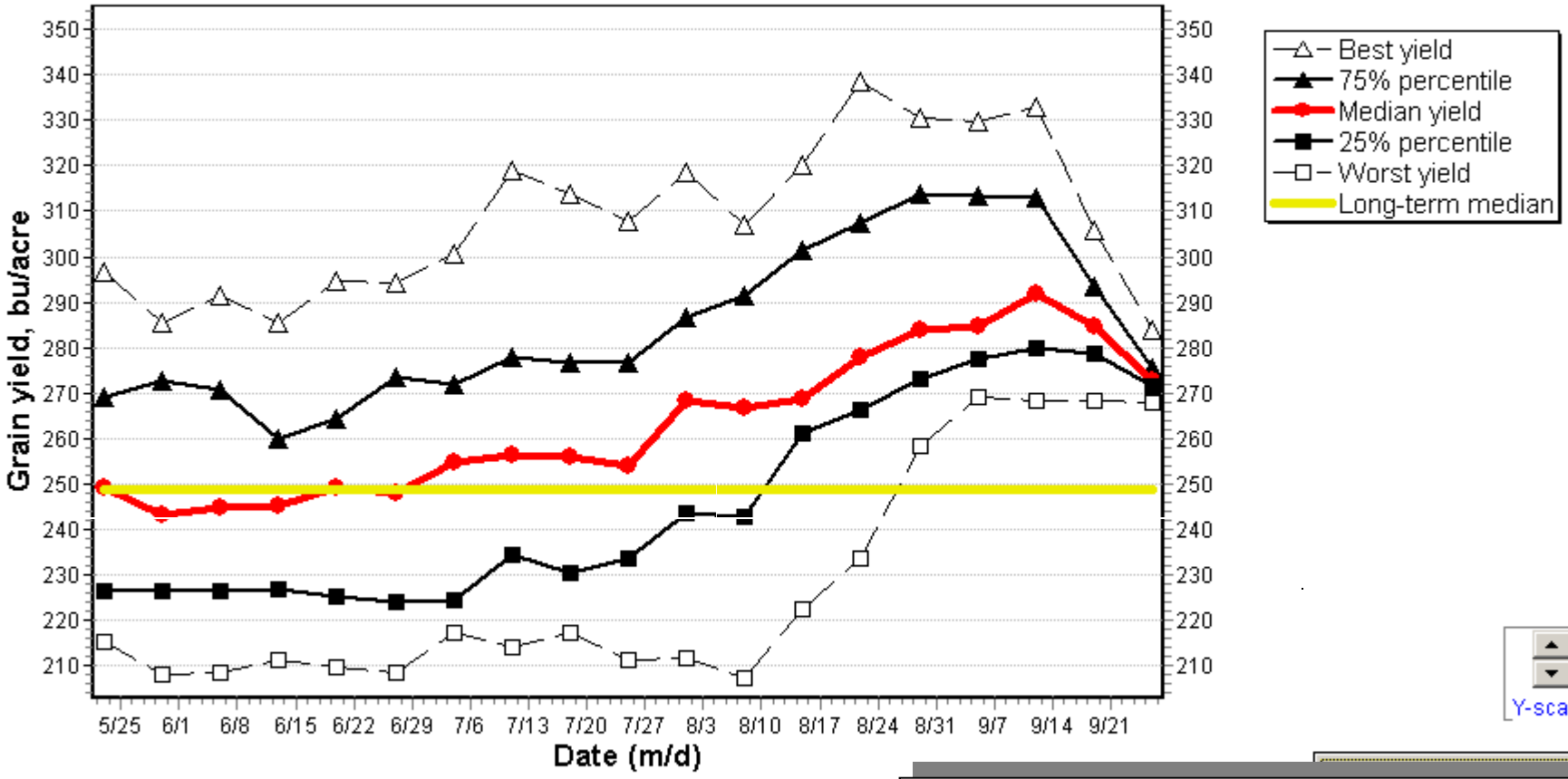
Input | Results | Chart | Growth | Weather | Water | Yield trend

Hybrid-Maize

Nebraska Lincoln



Include:

- [x] Best and worst yield
- [x] 25% and 75% percentile

Lincoln EI, 2004, 30k/a
Maturity: 09/30/04
Measured yield: 264 bu/a

Location - treatment	Grain yield (bu/acre)	
	Measured	Predicted
Lincoln, NE – siL, corn following soybean, 35,000 pl./a, irrigated, 223 lbs N/acre, 4-way split, +P and K	285	287
Bellwood, NE – IS, continuous corn, 31000 pl./a, irrigated, 335 lbs N/acre, 5-way split, +P and K	268	273
Cairo, NE – siL, continuous corn, 32500 pl./a, irrigated, 300 lbs N/acre, 2-way split, +P and K	276	275
Paxton, NE – IS, continuous corn, 31800 pl./a, irrigated, 300 lbs N/acre, 3-way split, +P and K	258	257
Brunswick, NE – siL, corn following soybean, 35000 pl./a, irrigated, 259 lbs N/acre, 3-way split, +P and K	277	279
Scandia, KS - 28000 pl./a, irrigated, 300 lbs N/acre, 4-way split, +P, K, and S	223	219
Scandia, KS - 42000 pl./a, irrigated, 230 lbs N/acre, 4-way split, +P, K, and S	251	252
Champaign, IL, corn/oats/hay rotation, rainfed corn, lime plus fertilizer (Morrow Plots long-term experiment)	261	286

Validation

University of Nebraska Lincoln

Dryland corn		2001	2003
Hybrid		P 33B51	P 33B51
Planting		14-May	13-May
Maturity (R6)		12-Sep	5-Sep
Final population		22,000/a	23,000/a
Measured yield	Combine (160 acres)	139	123
(bu/acre)	Hand-harvest (24 locations)	154	127
Simulated yield	Planting date - hybrid GDD	145	138
(bu/acre)	Estimated date of maturity	7-Sep	16-Sep
	Planting date - maturity date	158	125

Dryland corn, Mead, NE, CSP site 3

Validation

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- Sensitive to dates of growth stages entered or predicted (silking and physiological maturity).
- Mostly tested with plant populations ranging from 25,000 to 45,000 plants/acre.
- Does not account for different row spacing.
- Interactive effects of plant density and temperature on growth are not well understood.
- Limited validation for water-limited conditions. Performance under extreme dryland conditions with low plant populations is uncertain.
- Default soil physical properties for different soil texture may not represent actual properties.

Uncertainties

- Validation & possibly modification of the water balance module for simulating dryland and irrigated cropping
- Alternatives for entering soil moisture at the beginning of the growing season
- Revision of functions describing response to plant density
- Module for making NPK management decisions
- Module for simulating carbon and nitrogen turnover from crop residues and short- as well as long-term changes in soil C and N
- Grain dry-down prediction

Possible future improvements

- Hybrid-maize represents the current scientific understanding of corn growth and development on a dynamic and mechanistic basis.
- Hybrid-Maize allows evaluating options for corn management and making decision before, during, and after the growing season.
- Hybrid-Maize can contribute to better exploiting the climatic-genetic site yield potential, leading to more efficient use of resources and higher profit.
- Hybrid-Maize also has a great educational value: understand what drives crop growth in the field.

Summary

Hybrid-Maize model - Mozilla Firefox

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http://www.hybridmaize.unl.edu/

hybridmaize.unl.edu

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Hybrid-Maize

A simulation model for corn growth and yield

Agronomy & Horticulture

Nebraska Lincoln

Home

NEW **Hands-on training on applications of the Hybrid-Maize model (along with WeedSoft) in Feb and March 2005. Limited slots. Click to go to the flier and registration.**

Features of the model

How to run a simulation:

- **Decide a simulation mode**
- **Collect input data**
- **Set inputs and run**
- **View results**

Examples of model applications

FAQ

User's guide/documentation

Brochure: (3-page), or (3-fold)

Publications

Acknowledgements

Contact model authors

Trial version free download

Online purchase:

- **Hybrid-Maize model software**

What does the Hybrid-Maize model do?

Hybrid-Maize is a computer program that simulates the growth of a corn crop (*Zea mays* L.) under non-limiting or water-limited (rainfed or irrigated) conditions based on daily weather data. Specifically, it allows the user to:

- Assess the overall site yield potential and its variability based on historical weather data;
- Evaluate changes in attainable yield using different combinations of planting date, hybrid maturity, and plant density;
- Analyze corn yield in relation to the timing of silking and maturity in specific years;
- Explore options for optimal irrigation management;
- Conduct in-season simulations to evaluate actual growth up to the current date based on real-time weather data, and to forecast final yield scenarios based on historical weather data for the remainder of the growing season.

Hybrid-Maize does NOT allow assessment of different options for nutrient management nor does it account for yield losses due to weeds, insects, diseases, lodging, and other stresses.

Hybrid-Maize has been evaluated primarily in rainfed and irrigated maize systems of the US Corn Belt. Caution should be exercised when applying this model to other environments as this may require changes in some of the default model parameters.

As with all simulation models, **Hybrid-Maize** still represents a simplification of the 'real-world' system and, as such, model predictions may differ from actual outcomes. Therefore, the results of model simulations should be considered approximations and not taken as fact.

For questions, comments or suggestions, contact:

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